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Improving Young Child Feeding in Eastern and Southern Africa

Household-Level Food Technology

Proceedings of a workshop
held in Nairobi, Kenya,
12-16 October 1987

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Improving Young Child Feeding in Eastern and Southern Africa

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Editors: D. Alnwick, S. Moses,
and O.G. Schmidt

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Abstract

The weaning period, that is the period in a young child's life when supplementary foods are introduced to complement breast milk, poses great nutritional risk to children in developing countries. By the end of the second year of life, one-third of children in eastern and southern Africa are chronically malnourished. The following factors contribute to the growth faltering commonly observed in weaning-age children: low nutrient intake, high incidence of diarrheal disease (often caused by contaminated weaning foods), and recent declines in duration and intensity of breastfeeding.

Food scientists, nutritionists, and health planners working in Africa and South Asia met in an international workshop to examine household-level food technologies that hold promise for improving nutrition of infants and young children. After reviewing current knowledge of breastfeeding and weaning practices in eastern and southern Africa, participants discussed the use in weaning diets of fermented foods and germinated flour, for both improved nutrient intake by young children and decreased risk of food contamination. Research that should be conducted into the effectiveness of the food technology was identified and its diffusion at the community level discussed.

This publication contains the proceedings, conclusions, and recommendations of the workshop. It is directed at scientists and health planners who are involved in nutrition research and developing programs to improve feeding of infants and young children in developing countries.

Résumé

Le sevrage, c'est-à-dire la période où l'on commence à donner des aliments solides à un jeune enfant en complément du lait maternel, présente de graves risques nutritionnels pour les enfants dans les pays en développement. Dès la fin de leur deuxième année, le tiers des enfants en Afrique orientale et australe souffrent de malnutrition chronique. Les facteurs suivants sont à l'origine du retard de croissance que l'on retrouve couramment chez les enfants en âge d'être sevrés : carence nutritionnelle, forte prévalence des maladies diarrhéiques (qui s'expliquent souvent par la contamination des aliments) et diminution récente de la duré et de l'intensité de l'allaitement maternel.

Des spécialistes des sciences de l'alimentation, des nutritionnistes et des planificateurs de la santé travaillant en Afrique et en Asie du Sud se sont réunis dans le cadre d'un atelier international afin d'examiner des technologies alimentaires applicables au niveau des ménages qui semblent prometteuses pour améliorer la nutrition des nourrissons et des jeunes enfants. Après avoir examiné les connaissances actuelles en matière d'allaitement au sein et les pratiques de sevrage en Afrique orientale et australe, les participants ont discuté de l'utilisation, au cours du sevrage, d'aliments fermentés et de farine germée, tant pour améliorer l'apport nutritionnel chez les jeunes enfants que pour diminuer les risques de contamination des aliments. Ils ont également discuté des recherches qu'il y aurait lieu d'entreprendre sur l'efficacité des technologies alimentaires et sur leur diffusion dans la collectivité.

Cette publication fait un compte rendu des discussions de l'atelier et présente ses conclusions et ses recommandations. Elle s'adresse aux scientifiques et aux planificateurs de la santé qui participent à des recherches en matière de nutrition et à l'élaboration de programmes visant à améliorer l'alimentation des nourrissons et des jeunes enfants dans les pays en développement.

Resumen

El período de destete, es decir, aquel período en la vida de un niño en que se introducen en su dieta alimentos suplementarios para complementar la leche materna, representa un gran riesgo nutricional para los niños de países en vías de desarrollo. Hacia el final de su segundo año de vida, un tercio de los niños en Africa oriental y del sur muestran señales de malnutrición crónica. Los siguientes factores contribuyen al crecimiento vacilante que se observa comúnmente en los niños que se encuentran en edad de dejar la lactancia materna: baja ingestión de nutrientes, alta incidencia de diarrea (a menudo causada por alimentos para el destete contaminados), y nuevas disminuciones en la duración e intensidad de la alimentación proveniente del pecho de la madre.

Científicos del campo de los alimentos, especialistas en nutrición y planificadores de la salud que trabajan en Africa y en el Sur de Asia se reunieron en un taller internacional para examinar las tecnologías de alimentos que se utilizan en el hogar y que prometen bunos resultados en el mejoramiento de la nutrición de lactantes y niños pequeños. Después de analizar el conocimiento que existe actualmente sobre la alimentación recibida a través del pecho de la madre y las prácticas que se utilizan para el destete en el oriente y sur de Africa, los participantes discutieron el uso en dietas para el destete de alimentos fermentados y harina germinada para que los niños pudan ingerir nutrientes mejorados y haya una disminución en el riesgo causado por la contaminación de los alimentos. Se identificó la investigación que se debe realizar sobre la efectividad de las tecnologías de alimentos y se discutió su difusión en el seno de la comunidad.

Esta publicación contiene las actas, conclusiones y recomendaciones del taller. Está dirigida a científicos y planificadores de la salud que participan en lainvestigación nutricional y en programas de desarrollo para mejorar la alimentación de lactantes y niños en los países en desarrollo.

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PREFACE

The period of weaning, during which a young child becomes accustomed to the change from a diet consisting solely of his or her mother's milk, to one totally devoid of it, may take a year or more, and in much of the world this is perhaps the most dangerous period of the child's life. Many will not survive it. Of those that do, too many will be stunted in body, and perhaps in mind, and never be able to attain the full promise of their birth.

There is no doubt as to the crucial importance of breast milk as a hygienic and nutritious food throughout the weaning period. But problems associated with the introduction of foods complementary to breast milk - of adequate nutritional and hygienic quality, in sufficient quantity, and at the appropriate time - are among the most critical for child survival and development in many countries throughout the world.

This report of a workshop, which addressed the question of what can be done at the household level to improve young child feeding and examined traditional technologies in the light of modern science, is therefore extremely timely and relevant. But however ingenious and simple a technology may be, it will not be "appropriate" unless it is compatible with the life-style and culture of the people, nor will it necessarily become assimilated merely because it is made available. Skills from many disciplines may be needed to bring about change in behaviour - if this is deemed desirable - on a large and sustained scale. The challenge is always there.

James P. Grant
Executive Director
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FOREWORD

This publication presents the proceedings of an international workshop held in Nairobi, Kenya, from 11 to 16 October 1987, sponsored principally by the International Development Research Centre (IDRC), the United Nations Children's Fund (UNICEF), and the Swedish International Development Agency (SIDA). The workshop reflects the continuing interest of all three agencies in the promotion of infant and young child nutrition, health, and development.

It has long been recognized in developing countries that the weaning period, between roughly the ages of 6 and 24 months, represents a period of particular risk to the health and nutritional status of young children. Infants usually grow well for the first 4-6 months of life, when exclusive or near-exclusive breastfeeding is generally practised. Growth begins to falter at about the age of 6 months, when foods to complement breast milk are required to sustain infant growth. Growth often continues to falter throughout the rest of infancy and early childhood, resulting in high levels of malnutrition, an important underlying cause of infant and young child mortality in developing countries.

There are many reasons for poor infant and young child growth and this workshop addressed two critical factors related to the consumption of supplementary foods: the low nutrient density (nigh bulk) of commonly used weaning food preparations and their frequent contamination by pathogenic organisms that cause diarrheal disease. The workshop recognized that attempts to improve young child nutrition must first and foremost include intensive efforts to promote breastfeeding throughout the weaning period, including the second year of life. Participants then devoted their attention to the scientific examination of two traditional methods of food preparation that hold promise for increasing the nutrient density of weaning foods and for decreasing the risk of contamination. These methods are sprouting or germination of grains, and lactic fermentation or souring of cereal-based porridges. These household-level technologies have traditionally been widely practised in eastern and southern Africa, but in many instances have fallen out of favour, due to the trend toward "modernization" and the shift in staple crop preference from sorghum and millet to maize.

Compared with the large volume of research that has been conducted over the years on milk-based weaning foods and on the development of commercial weaning products, the work that has been undertaken on traditional methods of preparing weaning foods has been almost insignificant. Yet, even when appropriate foodstuffs have been available, programs that have tried to introduce new and unfamiliar ways of increasing the nutrient intake of weaning age children through the use of supplementary foods have met with little success. It should, in principle, be easier and more effective to reintroduce, perhaps in a modified form, appropriate traditional methods of food preparation; the workshop brought together 70 food scientists, nutritionists, pediatricians, health educators, and program administrators from 19 countries to discuss and debate the scientific and policy aspects of this issue.

It is of course not sufficient to develop what appear to be appropriate and effective household-level food technologies, and assume that they will be adopted. Food products and methods of prepararion that are developed or tested in the laboratory, even when based on traditional practice, must be scientifically evaluated in the field. Promising technologies must then be transferred to the intended beneficiaries, because food is not nutritious until it is eaten. A multidisciplinary and multisectoral approach is required if the technologies that were the focus of this workshop are to be widely diffused; the organizers of the workshop are, therefore, to be commended for bringing together participants from such a wide variety of disciplines and institutions. It is our hope that this publication will bring the issue of appropriate household-level food technologies for improving young child feeding to the attention of scientists and planners involved in nutrition research and program development in developing countries, and in this way help to meet the needs of the intended beneficiaries - the world's disadvantaged children.

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The Overseas Development Administration, U.K. and the Centers for Disease Control, USA, sponsored the attendance of some participants. Invaluable administrative support for the workshop was provided by Carla Plummer, by Agnes Atsiaya and Alice Mbogo of IDRC, Nairobi, and by Judith Otieno of UNICEF, Nairobi. Finally, we would like to express special appreciation to all of the authors who worked so hard on revising their papers throughout the course of the workshop and to Katherine Kealey, the technical editor, without whose tireless and patient work this publication would not have been possible.

EXECUTIVE SUMMARY

Introduction

Throughout eastern and southern Africa, about one-third of all young children are chronically undernourished. This high prevalence of malnutrition is associated with high mortality rates in infants and young children, high morbidity rates, and suboptimal child development. Infants generally grow well for the first 4-6 months of life, but between 6 and 18 months of age, growth starts to falter and, by the end of this time the average rural child in the region is smaller than 97% of Western children of the same age. Reducing the severity and frequency of growth-faltering during this period could contribute substantially to improved survival, health, and development for children.

Growth-faltering coincides with the time that babies start to be given supplementary foods in addition to breast milk - the so-called "weaning period." Foods that are introduced to supplement breast milk (weaning foods) should meet a minimum standard of nutrition and hygiene and should be provided in sufficient quantity and at the appropriate time. In most developing countries, problems associated with the introduction of weaning foods are among the most critical for child health and development.

The weaning period poses three major nutritional problems for young children in the eastern and southern Africa region. First, weaning foods are frequently contaminated with pathogens that cause diarrhea, which directly contributes to malnutrition. Second, weaning foods made from the major staple foods in the region have a low nutrient density, mainly because they are high in unmodified starch and low in fat. Porridges prepared from such foods with a consistency acceptable to a 1-year-old child have an energy content about a third that of typical Western weaning foods. A young child must consume a large volume of porridge if its energy and other nutrient requirements are to be met during the period when breast milk alone is insufficient. Many children are unable to eat such quantities, resulting in insufficient intakes of energy, protein, and other nutrients. The problem is compounded if children are fed infrequently (because of other demands on the mother's time) or if appetite is reduced because of illness. The third major nutritional problem associated with the weaning period derives from the fact that, in some areas, breastfeeding duration and intensity have declined recently, resulting in the decreased intake of an important and hygienic source of nutrients. Of particular concern is that, in many countries, breastfeeding during the 2nd year of life is declining significantly.

To increase nutrient intake during the weaning period, several approaches have been undertaken by governments and concerned agencies in the region: these approaches include development of nutrition education programs; promotion of prolonged breastfeeding, together with the feeding of a nutritious weaning diet based on a mixture of locally available foods; improved environmental sanitation and personal hygiene; and the manufacture and distribution of special weaning foods or food supplements.

By and large, the results of these approaches have been disappointing, and overall impact on nutritional status has been slight. Many of the intended beneficiaries of such programs have not been able to practice the advice that was given. Several factors have contributed to this situation: inappropriate nutrition education messages, lack of money to purchase recommended food items, lack of time to prepare food, and insufficient local or governmental support to undertake effective programs.

There is alarming evidence that with worsening economic conditions in many countries in sub-Saharan Africa, the nutritional status of young children is actually deteriorating. Families who are unable to purchase or grow sufficient food may always have some malnourished members. Due, however, to the low nutrient density of typical weaning foods, to their frequent contamination with diarrhea-causing pathogens, and to insufficient breastfeeding, young children often fail to grow well, even when the overall availability and distribution of food is adequate to cover nutritional needs. It is timely, therefore, to reexamine approaches that hold promise for improving the quantity and quality of the nutrient intake of children during the weaning period.

To improve the nutrient intake of weaning-age children, food preparation technologies have been advocated that effectively increase the nutrient density of weaning porridges and reduce the risk of infection from them. Such technologies must be simple, easily understood, and culturally acceptable. Furthermore, the food products that result must be affordable, in terms both of cash and of labour time.

In addition to problems in distribution, the cost factor almost certainly rules out the use of centrally processed, packaged weaning foods as appropriate food products for most children. Instead, processes that require a minimum of equipment and that could be carried out in individual homes or possibly groups of homes would appear to be the most desirable technologies for producing appropriate weaning foods. Several traditional food technologies have commonly been used at the household level in eastern and southern Africa for food or beverage production. The workshop subjected these technologies to scientific scrutiny and debate, to determine whether they could help to improve nutrition during the weaning period.

The objectives of the workshop were

- To review current knowledge with respect to weaning practices among children in eastern and southern African countries, as well as nutritional problems associated with the weaning period;

- To discuss household-level food technologies that promise to improve nutrition of young children, focusing on the germination of flour and on the fermentation of cereal-based porridges;

- To identify research activities that must be pursued to establish the effectiveness and safety of such technologies; and
- To discuss the means whereby information about effective and appropriate household-level food technologies may be widely disseminated, and these technologies put into practice in communities and countries in the region.

The workshop began with the presentation of several papers that reviewed current knowledge in the general area of young-child feeding. Particular attention was paid to the crucial importance throughout the weaning period of breast milk as a hygienic and nutrient-dense food. Weaning practices in several countries in the region were then reviewed, with emphasis on the use of germinated and fermented food products in the weaning diet. Germination and fermentation are two traditional, household-level food technologies that have been proposed as effective and appropriate in helping to improve young-child nutrition.

The addition of a small quantity of germinated flour, rich in the enzyme amylase, to thick cereal porridges is known to reduce dramatically the viscosity of such porridges, allowing for the preparation of a more nutrient-dense food that is sufficiently liquid for a young child to consume. Although the technology for producing germinated flour is well known in the region, and the raw materials required are widely available throughout sub-Saharan Africa, this technique is not commonly used in preparing weaning foods. The workshop reviewed and analyzed experiences in sub-Saharan Africa and in South Asia with the use of germinated flour for improving the caloric density of weaning preparations. Potential problems with this technique were discussed, as were the ways of overcoming them.

Nonalcoholic fermentation of cereal porridges by lactic acid-producing bacteria is also felt to have some advantages in preparing weaning porridges. As a result of fermentation, the bioavailability of protein, vitamins, and minerals may be increased. Furthermore, fermentation preserves porridges and may make them more resistant to contamination by inhibiting the proliferation of diarrhea-causing microorganisms. Young children could, therefore, be fed more frequently, using the same batch of porridge. Many communities in eastern and southern Africa have traditionally used fermented or "sour" porridges as weaning foods; the workshop considered evidence for and against promoting the increased use of such porridges in this capacity.

After these deliberations, working groups were formed to draft the conclusions and recommendations that follow, regarding the food technologies, their potential role in community nutrition, and ways of promoting their widespread application. However ingenious and simple the technologies, they are not appropriate unless they are compatible with the beliefs and cultural practices of the people; they will not become assimilated merely because they are available. Skills from many disciplines are required to bring about behavioural change on a large scale. The recommendations from this workshop are directed at governments, agencies, and institutions concerned with effective and appropriate ways of improving nutrition, health, and development of young children. Changes in feeding practices are needed to achieve this goal; it is hoped that the recommendations will be of value to those who are in a position to effect these changes.

Conclusions and Recommendations

General

The following are five general recommendations aimed at improving the feeding of infants and young children:

- Collaboration has been inadequate among the various professionals working in the field of human nutrition: food scientists, nutritionists, health workers, and program administrators. Increased interaction among these groups would facilitate those multidisciplinary approaches advocated to solve problems in human nutrition. The International Union of Nutrition Sciences (IUNS) and the International Union of Food Science and Technology (IUFoST) have important roles to play in this respect.

- Breastfeeding is of fundamental importance in the weaning process. Breast milk can provide up to 50% of energy requirements of children during the 2nd year of life, as well as significant amounts of protein, vitamins, and minerals. Breastfeeding should therefore be promoted for at least the first 2 years of life, and the addition at age 4-6 months of supplementary foods should not result in decreased breast-milk consumption.

- Lactic fermentation of foods is a household-level food technology that is widely practised in eastern and southern Africa. The resulting food products fulfill many of the characteristics of optimal weaning foods. In particular, there is strong experimental evidence that lactic fermentation inhibits the proliferation of bacterial pathogens, extending the time during which these foods can be safely stored. In thus allowing for more frequent feeding without more frequent cooking, fermentation saves on time and energy requirements. There is also considerable evidence that lactic fermentation can increase the nutrient availability of foods, and some evidence that viscosity may also be reduced. For these reasons, it is recommended that, in areas where fermented foods are already employed as weaning preparations, their use should be supported and encouraged. Before launching a wide-scale promotion and diffusion of the technology, however, further research is advisable.

- Germination or sprouting of cereals such as sorghum and millet to produce a malt is traditionally practised in many parts of Africa. This malt is generally used in preparing alcoholic beverages for adult consumption; in some areas, however, it is used to produce nonalcoholic foods or beverages. In India, legumes also are traditionally sprouted and used in food preparation. There is clear evidence from both Africa and Asia that the use of a malt as an additive to a weaning food will reduce the viscosity of that food; this will allow foods with greater nutrient density but with acceptable consistency to be prepared. Despite the promise here for overcoming the problem of dietary bulk, the workshop felt that before the use of malt in weaning food preparations is widely advocated, further research is required into the safety and effectiveness of the process.

- The possibility of combining germination and fermentation in preparing weaning foods warrants further investigation. Foods prepared in this way should have a high nutrient density and low dietary bulk, as well as a lower risk of microbiological contamination.

Particular

The following is a series of specific recommendations grouped around five important topics for consideration with respect to infant and young child feeding practices.

Breastfeeding

- Governments, nongovernmental organizations, and health workers should encourage the promotion and protection of breastfeeding during the 2nd year of life. These efforts should include the development of positive societal attitudes toward longer duration of breastfeeding.
- National data on breastfeeding practices should be routinely collected, and national objectives set for breastfeeding duration, breastfeeding patterns, and related aspects of maternal nutrition.
- Constraints to good breastfeeding practice need to be identified nationally and internationally. Special attention should be directed toward women whose work, paid or unpaid, takes them away from their children. Legislation should be developed and enforced to provide for increased maternity leave and for women who wish to breastfeed in the workplace.
- Breastfeeding during illness provides essential food and fluid to the often anorexic child. Interruption of breastfeeding during illness, and particularly during diarrheal disease, is harmful. In situations where children under 2 years of age must be hospitalized, provision should routinely be made for mothers to stay with them.
- National marketing codes for food products for infants and young children should be strengthened and enforced. The free distribution of milk powder should be controlled and coordinated.

Anorexia

- Illnesses in young children, particularly febrile illnesses and diarrheal disease, are often associated with anorexia. It is important that the child continue drinking and feeding through illness. Increased use of breast milk and, depending on the local situation, the use of more liquid foods, sour porridges, sweet foods, and any special favourite foods is recommended.
- It may be beneficial to increase the frequency of feeding, using smaller amounts of food than usual. As feeding is on the whole a social activity, efforts should be made to maintain it as such during illness.
- Research is required to achieve a better awareness of cultural beliefs and practices during diarrheal and other illnesses, and during recovery periods. It is important to understand whether

the lower food intake observed among ill children is the result primarily of a physiological process that suppresses appetite, or of withholding of food by the child caretakers.

- In areas where forced feeding of children is customary, the practice should not be discouraged. Studies are required, however, to investigate the potential problem of aspiration pneumonia.

Supplementary Foods for Young Children

The following is a list of optimal characteristics of supplementary foods for young children. It is not meant to be exhaustive, but to serve as a framework against which the appropriateness of weaning food preparations may be considered.

- The food should be dense in energy and other nutrients, have a high nutrient bioavailability, and be low in antinutritional factors.
- The food should be low in viscosity, so that a large quantity may be consumed at a single sitting. This has the important effect of reducing the number of meals required to satisfy the daily energy requirements of a young child.
- The food should be inexpensive to prepare, in terms both of the ingredients and of the fuel required for cooking.
- Foods should be prepared from crops that are agroclimatically suitable, using appropriate technologies, such as village dehullers, for preparing the base materials.
- As far as possible, the ingredients used should be ones that are available in all seasons; when ingredients are temporarily unavailable, it should be possible to substitute others.
- The food should be convenient and easy to prepare, involving few utensils, and requiring short cooking, preparation, and feeding times.
- Both the ingredients and the finished products should be ones that can be stored safely at the household level.
- The food should be culturally acceptable and pleasing in taste, appearance, and texture to the child and to the mother.
- The method of preparation should be such that it can be easily taught and understood and, ideally, should be based on practices that are traditionally familiar.
- The food should be such that it would be difficult or impossible to give by feeding bottle.

Fermented Foods

- Research is needed on the inhibitory effects of fermentation on the growth of various diarrhea-causing pathogens under field conditions, where ongoing contamination may occur. The focus of attention should be those pathogens that are important in specific situations, but that have not already been studied. To help examine the mechanisms for decreasing microbial growth, the rates of acid production during fermentation should be determined. Comparisons should be made, under field conditions, between fermented and nonfermented foods, with respect to levels of contamination.

- Research should be undertaken to determine whether the use of fermented foods can reduce the incidence, duration, and severity of diarrheal disease episodes in children at the community level, and, if so, whether this may lead to improved nutritional status. In such research, ethical issues must be carefully considered, and the studies should be undertaken in areas where fermented foods are or have been in common use - where they are perceived as posing no threat to young children.

- More detailed information on the use of fermented foods in the eastern and southern Africa region should be obtained, including information on ingredients, processing and preparation techniques, consumption patterns (past and present), shelf life, local names, and the viscosity and pH of commonly used preparations.

- The fermentation process should be examined to determine whether it results in increased availability of tryptophan/nicotinamide, and may therefore be of value in helping to prevent pellagra.

- A better understanding should be gained regarding popular perceptions, both positive and negative, of the use of fermented foods. Where the technology has been abandoned, the reasons for its abandonment should be studied. In some communities, it is considered acceptable to feed fermented foods only to older children and adults; the reasons for not supplying these foods to infants and young children should be examined. Because foods that are too acidic may not be acceptable to some individuals, a study should be undertaken of the acceptability of weaning food preparations that are acidified artificially.

- More information is required on household food budgets in relation to the cost of weaning foods, on the extra costs involved in fermenting foods, and on any savings of time and energy.

- If the use of fermented foods is to become widely adopted, their preparation must become an accepted part of everyday life. For this to occur, mothers and other consumers must be involved in developing the technology. Individuals who have experience with fermented foods can be recruited as teachers and leaders. It may be helpful to incorporate food processing into an existing routine. A positive attitude on the part of friends and neighbours can act as a powerful influence in developing positive feelings about the technology.

Germinated Flour

- Detailed documentation is required on the extent to which the germination process has traditionally been used in eastern and southern Africa for food and beverage preparation. Particular attention should be paid to the traditional use of germination in the preparation of weaning foods.

- Research should be conducted to determine whether children who are fed porridge treated with germinated flour consume more energy on a daily basis than children who are fed ordinary weaning porridge. The impact on breast milk intake of consumption of energy-dense weaning porridges should also be examined. Studies employing a quasi-experimental design, with experimental and control sets of villages, are needed to evaluate the effectiveness of germinated flour in increasing the nutrient intake of children under field conditions. Outcome variables could also include incidence of diarrhea, micronutrient status, and child growth. Studies should also look for possible adverse effects, such as the development of diarrhea and vomiting (especially if food is not reheated and enzyme activity is allowed to continue). It is recommended that this kind of study be conducted in Tanzania, where the use of germinated flour is already widespread.

- Little is known regarding nutrient absorption from millet- and sorghum-based weaning porridges. Research is needed on this topic, including work on whether digestibility, nutrient absorption, and the bioavailability of protein and minerals can be improved through germination or through the addition of germinated flour.

- Some varieties of fresh sorghum sprouts contain small amounts of cyanide. In areas where the technology is already being used for brewing beer or for other purposes, the risk of cyanide poisoning from sorghum sprouting appears to be minimal. Nevertheless, cyanide levels found in germinated sorghum require further study. Products to be examined must include germinated sorghum before and after the removal of roots and shoots, and before and after sun drying. Samples of weaning foods should also be taken during preparation and at the point of ingestion, and these samples examined for cyanide content. The effect on cyanide content of adding germinated flour to porridges at different temperatures should also be studied.

- There is no evidence of greater risk of aflatoxin contamination with cereal-based weaning porridges with added germinated flour than with untreated porridges. It is recommended, however, that the potential problem of aflatoxin contamination be kept in mind, and that raw materials for weaning food preparation, including sprouted grains, therefore be clean and free from mould.

- Acceptability trials of amylase-rich foods are needed at the community level. Palatability to both children and mothers should be examined. There should be an investigation into the optimal ratio of germinated flour to base ingredient, in terms of product acceptability and of preparation time. This ratio will vary with the type of grain that is germinated, the cooking temperature, and the time allowed for enzyme action to occur.

- Under village conditions, the shelf life of germinated flour should be studied with respect to microbiological contamination, rancidity, and enzyme activity. There should also be an examination into the risk of contamination by the addition after cooking (either with or without reheating) of the germinated flour.

- The economic implications of germinated flour production at the household and village level must be studied. The economic advantages and disadvantages should be considered in comparison with other methods of weaning-food preparation. Included in such a study would be consideration of time required by the production process, implications for intrafamily food distribution, and the cost and potential advantages of providing ready-made sprouted flour to households, particularly in those areas where germination technology is unknown.

- There should be more research into the viscosity-reduction effect of adding germinated flour to the raw flour used in preparing weaning porridges before cooking. If this is effective, it would overcome concern related to the possibility of contaminated germinated flour added to weaning foods after cooking, introducing pathogenic microorganisms. In promoting the use of germinated flour, the occurrence of the dramatic change in consistency should be emphasized. Direct demonstrations of the process are recommended, and these can be carried out with large groups. A key promotional message should be that larger quantities of food can be consumed by children at a single meal. Care should be taken, however, to ensure that this does not detract from the importance attached to the continued consumption of breast milk.

Session I

Issues in Improving Child Feeding

DO WE NOW HAVE SOME REAL SOLUTIONS FOR YOUNG CHILD MALNUTRITION?

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Abstract *The problem of nutrition in developing countries can be divided into four major categories: micronutrient deficiencies, malnutrition related to breastfeeding and bottle feeding, malnutrition related to other aspects of young-child feeding, and maternal malnutrition. No major progress has been made in alleviating any of these; during the past decade or two, however, there has been some progress in deciding where the most promising solutions may lie. The exception here is the third category, which poses a nutrition problem that is the most widespread and the most difficult to solve. The field of nutrition has changed so much in its analysis of the causes of young-child malnutrition and in its prescriptions for solutions, that it is losing credibility in many quarters. It can hardly be said that the "nutrition factor" is taken seriously today in the development planning of most countries. The two technologies discussed at this conference - germinated flour and fermentation - are considered by many to be far superior to most approaches so far tried for improving the diet of the young child. If this proves to be the case, there will be hope that the "nutrition factor" may yet come into its own.*

The field of nutrition is at risk of getting a bad name. We nutritionists receive a great deal of training; we hold extensive discussions and workshops; we recognize the importance of, and attempt to implement, an intersectoral approach to the complex causes of nutrition problems. Where, however, can we view the fruits of this labour - of this activity and investment? Is there, for example, any tangible proof of the impact of our work on levels of malnutrition? Can it indeed be said that we are needed at all? I suspect that the field of nutrition is at a juncture in its evolution: its survival as a factor in the development process could depend on a successful exploration and dissemination of the new technologies discussed at this workshop.

Problems and Progress

To justify a dramatic statement such as this, I must begin by dividing the major nutrition problems of the developing world into four categories: micronutrient deficiencies, malnutrition related to breastfeeding and bottle feeding, malnutrition related to other aspects of young-child feeding, and maternal malnutrition (other than micronutrient deficiencies).

Although nearly all these problems are closely linked to poverty or scarcity of resources, we tend to think of them as being amenable to purely technical solutions, at least in the short and medium term. With good planning and satisfactory levels of outside financial assistance, most developing countries could, to a great extent, eradicate these problems. Potential solutions include nutrient supplementation, food fortification, agricultural or gardening interventions, and nutrition education. It is gratifying to see in recent years that certain organizations - the ACC/SCN, the International Vitamin A Consultative Group, and the International Consultative Group on Iodine Deficiency Disorders - have begun to develop concrete plans for seeking funding sources and, in general, for pursuing an advocacy approach toward implementing some of these long-overdue solutions.

Potential solutions for malnutrition related to breastfeeding and bottle feeding can be divided into three categories: protection of breastfeeding where traditional patterns are still strong; support of breastfeeding where the modernization process threatens traditional confidence in it; and promotion of breastfeeding in industrialized settings where its value is no longer appreciated.

In recent years, some progress has been made in protecting breastfeeding. This progress is the result of the World Health Organization (WHO)/United Nations Children's Fund (UNICEF) International Code of Marketing of Breast-Milk Substitutes and of other initiatives - principally those of UNICEF, the International Baby Food Action Network (IBFAN), and some national governments. More work, however, is needed in this area: one important example would be the establishment of measures to restrict the availability of feeding bottles, particularly those made of plastic.

In the "support" category, some effort is underway in terms of training health-workers and lobbying for increased maternity benefits for working women. The "support" side of the triangle, however, is still neglected: breastfeeding mothers' voluntary groups often constitute the only available source of support for women who are breastfeeding. For women with particular problems, the ideal may lie in the combined support of both a health professional and a breastfeeding counsellor, whether paid or voluntary. Although some faltering has appeared in the last year or two, breastfeeding promotion has made progress in industrialized countries and, recently, in some developing countries. In conclusion, we are beginning to identify and even to implement some of what needs to be done, but we are far from being able to say that we have eliminated much of the malnutrition caused by inappropriate bottle feeding.

The last two categories of nutrition problems - malnutrition related to young child feeding and maternal malnutrition - are associated with a lack of adequate food intake, although microbial and parasitic infections often play a large role. I believe it to be a fair generalization to say that among the people who suffer from these types of nutrition problems, the common factor is a lack of control over personal food intake. People who for this reason are vulnerable are those who are institutionalized, those who are too young to feed themselves, and those who cannot grow or buy enough food. There will be no purpose served in continuing to tell poor pregnant women to eat more if they intentionally restrict their diets to get smaller newborns and, as they believe, easier deliveries. Even for them, however, as for those pregnant women to whom we give food supplements, our real goal is to improve not so much the nutritional status of the mother, as that of the newborn. As long as the mother gets enough space between births and can afford the food, she will in the long run probably recover her nutritional status. I do not believe that sane people go hungry because they are too stupid to eat.

Clearly, most maternal undernutrition is closely linked to poverty, and I suspect that the Women in Development movement's emphasis on income generation and on securing resource control for women is also the right long-term strategy for solving maternal undernutrition. In the short term, however, it can be seen that where income generation requires physical exertion on the part of women, then nutritional status must be made a first priority.

Failures and Hopes

Although we now seem to know a certain amount about how to deal with problems in the other categories, the relentless statistics on young-child malnutrition continue to stare at us, as though from the eyes of the starving children they represent.

Through the 1960s and the first half of the 1970s, the field of nutrition attracted growing attention and mobilized an impressive array of donor agencies: United Nations (UN) bodies, agricultural research stations, and even private industry collaborated on approaches to the many problems. The protein quality and quantity of grains was being improved; field trials of amino-acid fortification were under way; and factories to produce low-cost, high-protein weaning foods were beginning to appear. In 1973, Alan Berg published The Nutrition Factor, which described these and other promising nutrition interventions. The book announced that the time had come when nutrition could no longer be ignored. Its integral role in many aspects of the development process demanded that the "nutrition factor" begin to receive the attention it deserved in development planning.

Meanwhile, the foundations of much of this enterprise began to come into question. In 1974, Donald McLaren published in Lancet an article entitled "The great protein fiasco." In terms as provocative as his title, he marshalled evidence from several easily available sources to show that pure protein deficiency simply was not a problem. Take almost any common diet in the world, increase the amounts eaten to the point where energy needs are met, and you will almost always find that the "protein gap" will disappear. (Cassava-dominated diets are an exception. It is important to keep this in mind in the present context: because germination and fermentation technologies may increase the feasibility of making such a diet energy sufficient, the potential is created for a pure protein deficiency.) What you achieve by increasing the protein content of an energy-deficient diet is to a great extent merely the nitrogen enrichment of urine! Most of the extra, relatively expensive protein is burned for energy.

Although after the appearance of McLaren's article attention and funding were being quietly withdrawn from protein programs, enthusiasm was growing for nutrition planning. Systems analysis revealed that the right kinds of intersectoral cooperation could produce solutions, provided that there was political will to catalyze the process. In the meantime, a vacuum began to develop in the international nutrition field. For one thing, this field began to have less and less in common with industry (which, behind the scenes, has a lot to say about the direction of development assistance). Worse still, free-enterprise champions looked on with horror as activists and UN officials seemed to join forces in accusing industry of being part of the cause of the decline in breastfeeding. (One wonders whether this might have proven to be a boon to the current vaccination campaign, in which drug companies, refrigerator manufacturers, development agencies, UN organizations, and ministries of health all work together toward a shared goal.)

In any case, the effect of this vacuum may have been to shift more attention to micronutrient deficiencies. Regarding young-child malnutrition, attention has focused increasingly on better measuring and monitoring of growth and of nutritional status. In casting about for solutions to the problem, we nutritionists had an admittedly sparse fund of successful experience from which to draw. The most widely available journal articles and weaning-foods manuals advised us to develop recipes from local ingredients, and to recommend multimix porridges. This seemed to call upon our expertise in devising "balanced diets," something with which all Western-trained nutritionists and home economists are familiar. Why not teach people to group foods into categories of importance for achieving nutritional goals? Food quadrants and food groups entered curricula, showed up in health education teaching materials, and took root even in countries where they had no relation to local diets or concepts of foods. I suffered inwardly as I listened to the head of a health-education department in one African country: it appears that they were confused over the fact that despite the "proven success" of their nutrition-education message (studies had shown that all the mothers knew the importance of the three food groups), levels of malnutrition were remaining high, and were indeed increasing! When are we going to learn that what young children in resource-poor settings need is more food, and that anything that turns attention away from this fact is harmful?

This does not mean that we should give people food for their children. For a long time, we have found tempting the idea of merely shifting food from areas of surplus (North America and Europe) to areas of scarcity. Gradually, however, we are learning that food aid, when used for anything more than emergency purposes, is only likely to compound the problem.

Instead, we must look for ways to help poor mothers enrich the energy density of the food they feed their young children. We must look for ways to help busy mothers feed their young children more often. We must reduce levels of diarrhea, so that mothers who live in septic environments can help their children to retain more of the food they eat. We must not fool ourselves into thinking that anything will completely solve the terrible problems of young-child malnutrition until the poor, especially women, are given better opportunities for earning a living, are relieved of some of the crushing burden of work done merely to survive, are helped to space their children, and are assured of security in their old age. Neither should we throw up our hands and join those who say that nutrition as a field of endeavour has nothing to offer: this workshop, presenting as it does new ideas about the use of traditional methods of food preparation in solving child-feeding problems, may some day be viewed as a turning point for the field of nutrition.

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BREASTFEEDING: A NEGLECTED HOUSEHOLD-LEVEL WEANING-FOOD RESOURCE

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Abstract *Continued breastfeeding can make a significant contribution to child health and nutrition from 6 to 24 months of age, a period in which there is major risk of recurrent illness and malnutrition. Breastfeeding during the weaning period has, however, been largely neglected in research, in national statistics, and in nutrition programs, all of which often assume that breastfeeding will stop at 12 months or sooner. Three patterns of breastfeeding - exclusive, substantial, and token - are described here. Health planners are urged to set specific objectives for breastfeeding programs, and researchers are encouraged to determine breastfeeding patterns and actual breast milk intakes. The scattered data from the eastern and southern African region are presented on second-year breastfeeding prevalence and milk volumes. Breast milk contributes significantly to toddlers' intake of energy, protein, iron, vitamins A and C, and calcium. It offers protection against illness and therapy in diarrhea and provides an acceptable food for the anorexic child. Prolonged breastfeeding may also contribute both to fertility regulation and to an enhancement of the child's emotional development. A discussion of problematic current practices accompanies 13 recommendations for effective promotion, support, and protection of breastfeeding in the 2nd year.*

Breast milk can contribute significantly to the nutrition and health of children, not only after birth, but during the entire weaning period. Although the importance of breast milk for the newborn is widely recognized, breastfeeding from 12 to 24 months is too often disregarded or seen as relatively unimportant - an expression of love, but not a source of nourishment or protection.

For children in industrialized countries who are, on the whole, adequately nourished - eating a full range of foods at family meals and living in a relatively hygienic environment - continued intake of breast milk may not be vital to survival and development. For children in the developing world, however, the period from 6 to 24 months of life is one of major risks - often one of hunger and of recurrent illnesses that have serious cumulative effects.

What contribution can breastfeeding make to child survival and development in such conditions? We suggest that the contribution that breast milk makes after 6 months and, indeed, in the 2nd and 3rd years of life, has been undervalued. As a consequence, the practice of breastfeeding has been neglected in research, in national statistics, and in practical nutrition programs. A continuous decline in breastfeeding practice is too often accepted as an inevitable concomitant of development, so that this national food resource is discounted in planning. Yet it is vital that breastfeeding be promoted and protected throughout every child's 2nd year of life, along with other weaning foods essential to adequate growth and health. In this paper, we assess the contribution to health that can be made by a daily reliable intake of breast milk during the 2nd year of life.

Initially a trend in industrialized countries, breastfeeding has also declined in the developing world, especially among the urbanized or more educated populations; this decline has been widely documented (WHO 1981). Ironically, in industrialized countries, breastfeeding rates have now been rising steadily over the last 30 years, especially among educated women. In other words, while figures for breastfeeding are rising for the world's most privileged children, these figures are falling among the disadvantaged, for whom breastfeeding could make a life-or-death difference.

Many countries in Africa have high breastfeeding initiation rates (90-100%), yet public health statistics reveal numerous problems of morbidity and mortality related to poor feeding of infants and young children; this suggests that, despite good statistics for starting,

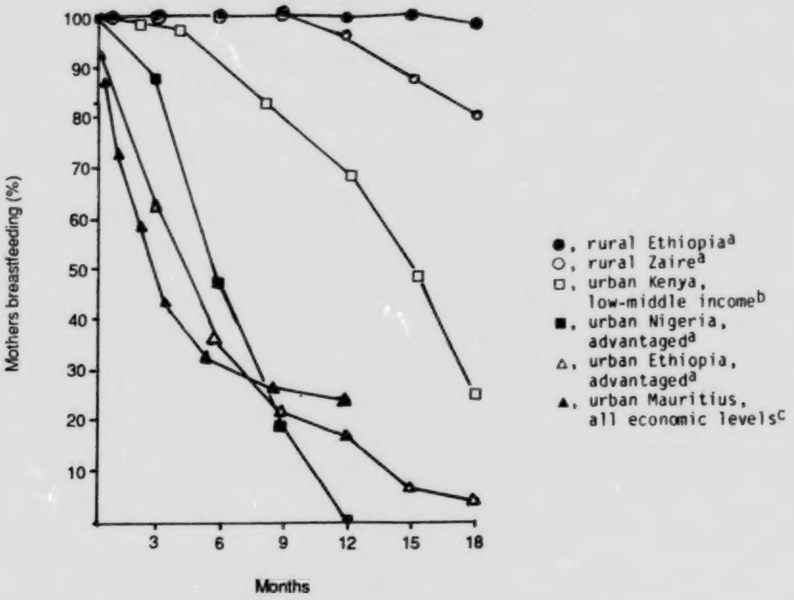

Fig.1. Breastfeeding initiation and duration. ([a]WHO 1981; [b]Winikoff et al. 1983; [c]Rajcoomar and Wong 1986.)

the duration of breastfeeding is often abbreviated (Fig. 1). More commonly in our region, the pattern of breastfeeding may be inadequate: a mother may say "yes" to the query "Are you breastfeeding?" whereas the child's actual intake of breast milk is negligible because the breastfeeding is sporadic.

Definitions

To say without clarification that a mother is "breastfeeding" is to make a statement of little significance, given the confusion that has arisen over the extremely varied use of the term. Sometimes it is taken to denote giving only the breast and nothing else. At the other extreme, the same word is used to mean any contact at all of baby and breast, regardless of frequency, length of feeds, effectiveness of sucking and of the milk ejection reflex, or any other consideration. Some researchers still put into a "breastfed" category those babies who receive bottle supplements from the 1st day (Feinstein et al. 1986), those who receive these supplements for no more than 25% of their feeds (Winikoff and Myers 1987), or those who were taken off the breast completely as early as 2 weeks of age (Gulick 1986). It is not surprising, then, that some studies reveal virtually no difference in nutritional or immunological status between the "breastfed" and the "not breastfed" groups. We propose that, in this discussion of the topic, three breastfeeding patterns be distinguished: exclusive, substantial, and token.

Exclusive breastfeeding means giving the breast in response to all the child's needs for food, drink, sucking, and perhaps comfort or soothing. Exclusive breastfeeding means that no other food or water or milk is given. It is usually practiced "on demand." The exclusively breastfed child will probably spend at least 1 h out of every 24 in sucking at the breast. The characteristic rhythm is one of frequent breast feeds, usually 10 or more in 24 h, either of long or short duration, with no very long intervals between. This has also been described as "unrestricted breastfeeding" by Newton (1971) and by Lawrence (1985).

Although the terms "partial breastfeeding" or "mixed breast and bottle feeding" are often used by researchers, it is important to distinguish between two breastfeeding patterns: substantial and token.

Substantial breastfeeding involves giving the breast in response to the child's needs, while allowing for the provision of food or drink supplements. The substantially breastfed baby of any age is still likely to show a rhythm of breastfeeding many times in a day and perhaps at night, still sucking for at least 1 h. With substantial breastfeeding, however, a long interval is common, either at night or during the mother's absence at work.

Token breastfeeding means limiting in frequency or duration the baby's time at the breast. If a mother is told to feed only on a timetable, to take the baby off the breast after a fixed number of minutes, and to keep the baby at some distance and not respond to its cries, then token breastfeeding occurs even before the introduction of other foods or drinks. In urban Africa, early use of supplements usually accompanies a token breastfeeding pattern. Disturbances in the mother-child bond, for whatever reason, may also promote such a pattern. Token breastfeeding in the first few months is negatively correlated with breastfeeding duration (Savage 1983; Lawrence 1985).

During the 2nd and 3rd years, as the intake of other foods increases, the breastfeeding child may gradually lose interest in active breastfeeding; a slow diminution from substantial to token breastfeeding is a natural part of the weaning process. The pattern of perhaps three breast feeds in 24 h (usually those hours associated with sleep) still has value for both child and mother, especially as it allows for a reestablishment of substantial breastfeeding whenever the child is ill.

The term "weaning" is also imprecise. It can mean "to add other foods to the baby's diet." It can also mean "to stop the baby from breastfeeding." Because nutritionists now emphasize continued substantial breastfeeding after the introduction of other foods, it may be unwise to use the ambiguous word "weaning." The French "sevrage" and the Kiswahili "kuachisha" have the same unfortunate implication - that the child is to be cut off or urged away from the breast. All these words suggest that the other foods are added as substitutes for breast milk, not as additions to it. We would define the term "weaning" as "the addition of other foods to mother's milk." The period during which this takes place is the "weaning interval."

Hofvander and Underwood (1987) suggest a diagram to represent all stages of the process: first, full or exclusive breastfeeding; a weaning interval, with complementary feeding; and cessation of breastfeeding (Fig. 2a). We suggest a further division, to distinguish between substantial breastfeeding and the token pattern (Fig. 2b). Unless, however, months are stipulated on the time axis, such diagrams are of little use in planning health education and other programs (Fig. 2c). Discussing the ideal timing of these different stages will help national planners to define needs and programs objectives. We have failed thus far either to set these objectives or to explain clearly what breastfeeding patterns are recommended at 12, 18, and 24 months; this explains, in part, why breastfeeding promotion has been ineffective.

There are two periods in particular that we may need to consider. Early in the weaning interval, we need to ensure that other foods are not substituted for breast milk. At some later stage, we need to ensure that a mother does not give a breast feed in place of a meal of other foods.

Breastfeeding Practices in Eastern and Southern Africa

What proportion of women in Africa breastfeed substantially, from the introduction of other foods (ideally by 6 months of age) right through the 2nd year? The length of this weaning interval is occasionally measured, but actual documentation is difficult to find. Most tabulations, including those of the United Nations Children's Fund (UNICEF) and the World Health Organization (WHO), stop at 12 months. Yet the majority of babies in this region are likely to be breastfeeding well into the 2nd year, considering that 75-95% of them are still breastfeeding at 12 months (WHO 1982; Kenya 1983; UNICEF 1987). National surveys in Botswana (1985) and Swaziland (1983) gave values of 74 and 58%, respectively. Where data have been collected

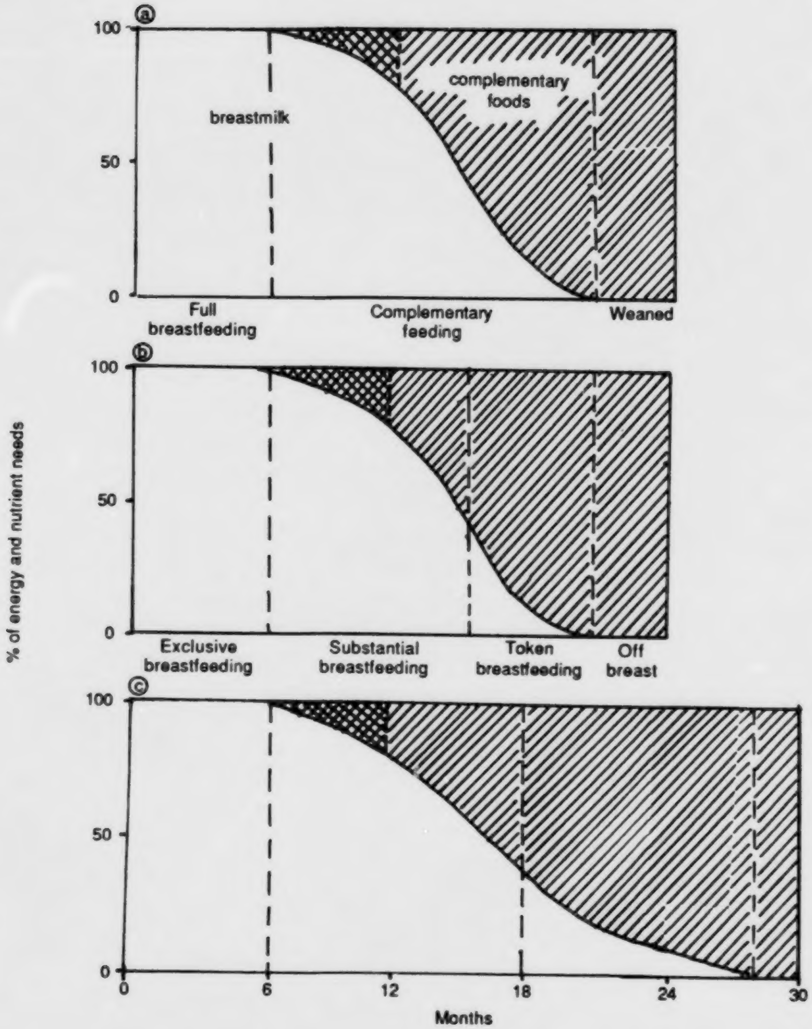

Fig. 2. Stages in the breastfeeding period: (a) Hofvander and Underwood's (1987) diagram, (b) three breastfeeding patterns, and (c) a possible program objective.

for our region on the 2nd and 3rd years, they should be viewed with some caution. The methodologies of the various studies, including sample selection, have varied greatly. Figure 3 attempts to bring together some available statistics. In Botswana, Ethiopia, Kenya, Swaziland, and Zaire, most women are still breastfeeding in the middle of the child's 2nd year. In Ethiopia, more than 75% of mothers, even among the urban poor, are breastfeeding when the child reaches 2 years of age, in rural Zaire, 60% are doing so. In Kenya, Oniang'o (1986)

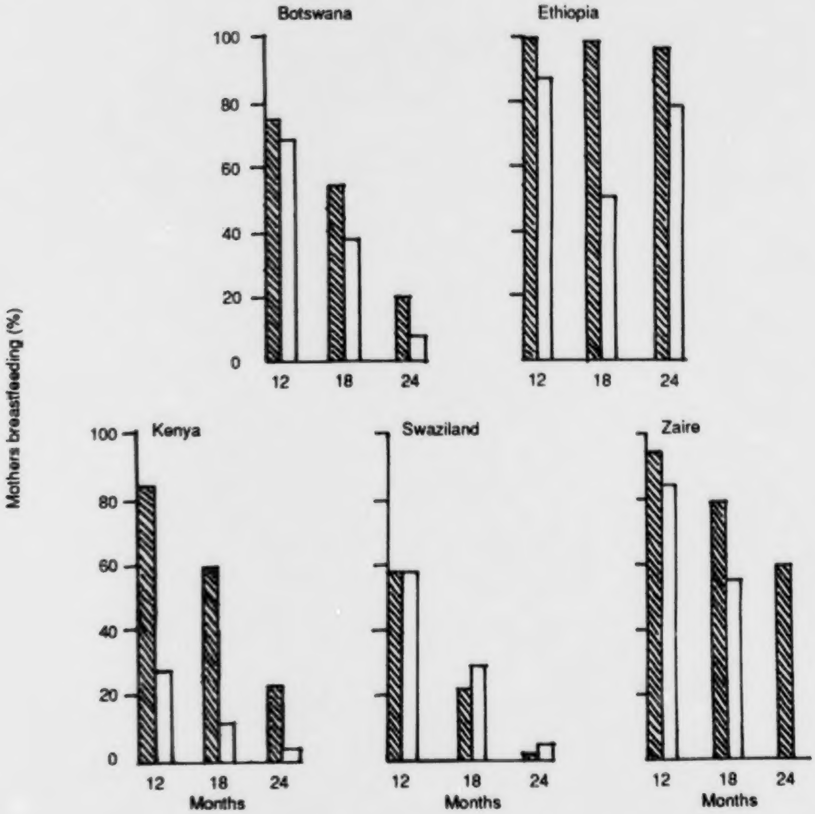

Fig. 3. Mothers breastfeeding in Botswana (Botswana 1984), Ethiopia (WHO 1981; Wolde-Gebriel 1981), Kenya (Kenya 1978/79, 1983), Swaziland (Swaziland 1983), and Zaire (Vis et al. 1981; WHO 1982). □ ,urban poor; ▨, rural.

found that 17% of rural women had breastfed a child in the past 3 years.

Demographers have projected that by the year 2000, a burgeoning percentage of Africa's population will be living in cities (Anyanwu and Enwonwu 1985). Will urbanization necessarily spell the end of prolonged breastfeeding? In Nigeria, there is a dramatic contrast between rural areas, with more than 90% of mothers breastfeeding at 16 months (WHO 1981), and the Lagos suburb where among middle- and low-income women only 25% were breastfeeding at 1 year (Anyanwu and Enwonwu 1985).

Khan's (1980) work in Bangladesh suggests, however, that urbanization need not lead to early cessation of breastfeeding. High rates were found among most poor women of urban Dhaka who were breastfeeding for long durations - 90% at 1 year, 63% at 2 years, and 15% at 3 years. Lactation of such long duration does not take place because of any physical anomaly in the women of Bangladesh or because of unusually good diets; it arises from culturally determined child-rearing practices. Were their breastfeeding behaviour to change appropriately, mothers who have practiced token breastfeeding would be able to lactate just as long as the Bangladesh women.

Breast Milk Volumes

Unfortunately, in investigating the intensity of breastfeeding in the 2nd year, most studies to date have gone no further than the simplest inquiry, "Are you breastfeeding, yes or no?" Vis et al. (1981), in a more detailed study in Kivu, Zaire, determined the number of breast feeds in 24 h, and measured 24-h volumes for 245 mothers. They found a remarkable consistency in the number of breast feeds - 12-14 per day through the first 2 years - and consequent high average milk yields throughout the period (Fig. 4).

By plotting day and night feedings separately for rural Machakos, Kenya, van Steenbergen et al. (1984) showed that for very actively employed farming women, night feeds outnumbered daytime feeds from 5 months onward. Night feeds contributed more breast milk than daytime feeds to the Machakos children from 5 months to 21 months (Fig. 4). Both Vis and van Steenbergen also noted seasonal variations in milk output. In the harvest season, breast milk output was higher and correlated in Machakos with increased frequency and length of feeds, and with more minutes of sucking per day.

Vis et al. (1981) showed that, because of the continuing pattern of substantial breastfeeding among the rural mothers of Zaire, average yields of breast milk declined very little, from 517 g/day at 1 month to 473 g/day at 24 months. Becroft (1967), in a study in New Guinea, found women with 2-year-olds producing 560 mL/day. In a study in Bangladesh, it was found that children of 12-17 months were receiving almost 600 mL of breast milk per day (Roy et al. 1984).

It is often claimed that poorly nourished women cannot breastfeed. Studies have shown, however, that such mothers can produce up to 700 mL/day during the first 6 months and 300-500 mL in the 2nd year (Jelliffe and Jelliffe 1978). In the lean preharvest season in Machakos, van Steenbergen et al. (1984) found levels of breast milk averaging 405 mL/day for infants of 12-17 months. Similarly, Whitehead (1985) found that 400-500 mL/day was being produced by Gambian "marginally nourished mothers" of infants of 18 months. At a time when there may be little else available to eat, breast milk is proving an irreplaceable source of nourishment, especially created for the most vulnerable family member - the child of 2 years or less.

Mothers can supply breast milk to their children for long periods without themselves suffering nutritionally. In Côte d'Ivoire, rural mothers, breastfeeding for 23 months on a diet composed mainly of yam, plantain, and cassava, showed no variation in weight throughout the period, leading Lauber and Reinhardt (1979) to remark: "These findings support the assumption that prolonged lactation has no unfavourable effect on the nutritional status of the mother." Nevertheless, the increased nutritional needs of lactating women, which surpass those of pregnant women, must not be forgotten when setting national nutritional policies.

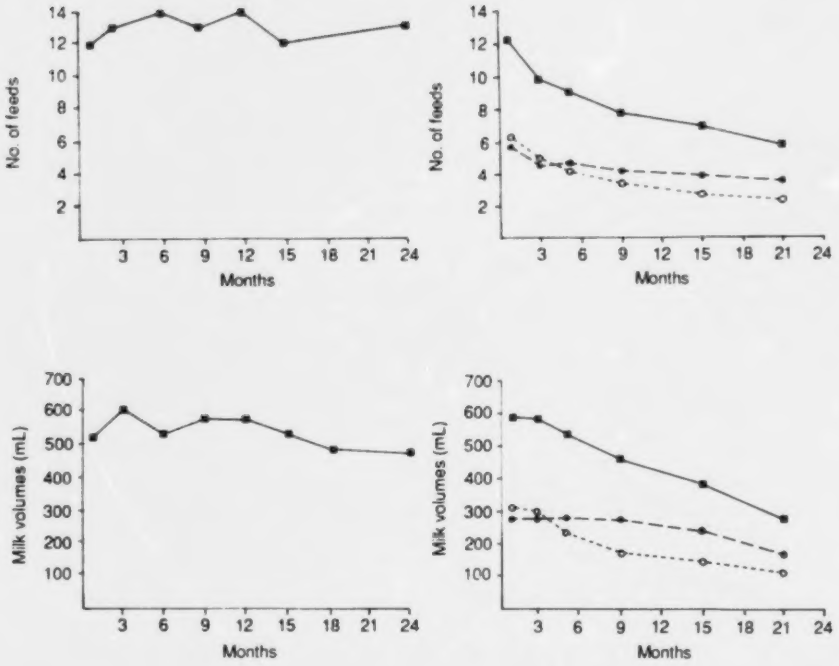

Fig. 4. Total number of breast feeds and milk volumes in 24 h in rural Zaire, left (adapted from Vis et al. 1981), and rural Kenya, right (adapted from van Steenbergen et al. 1984): ●, night; ○, day; ■, total.

Nutritional Importance of Breast Milk

Perhaps because so much of the research has been done in populations with abbreviated breastfeeding durations, breast milk seems not to have been perceived as an essential component of the diet past 6 months. Phrases such as "non-nutritional sucking" (Bowlby 1969) are misleading: in an established breastfeeding relationship, milk flows whenever the child sucks, and even an intake of 100 mL/day has nutritive value.

It is often remarked by health workers, trained in a system that discounts the nutritional value of breast milk after 6 months, that by the 2nd year the milk must be "thin," "weak," or otherwise changed in composition. This error in thinking may arise from the use of inaccurate training materials, which say that breast milk becomes "inadequate" after 6 months: the materials do not explain that this "inadequacy" applies only to quantity and not to the quality of the milk, which remains excellent. Helsing and King (1982) urge that this widespread error be corrected:

> It is of vital importance to understand and to teach others clearly that because an infant needs a supplement... it does not mean that the amount of milk produced by the breast has decreased and it does not mean that there is anything wrong with breastmilk, and it does not mean that breastfeeding should stop. It means that the amount of milk that can be produced has reached its upper limit and will not increase any more... The volume of milk will remain the same for a long time, provided the child is put to the breast as often as before... The quality of the milk is still excellent, and it continues to be the most important part of the baby's diet. Breast milk also continues to be the most important source of good-quality protein, vitamins, and other nutrients. All that the child needs is some extra energy and protein.

Energy Value

A study of Ugandan children up to 36 months (Rutishauser 1974) examined factors influencing low energy intake. These included poor appetite, high levels of infection, consumption of foods of low energy concentration, infrequency of feeding, and lowered breastfeeding prevalence. An attempt was made, using traditional weaning foods, to increase the frequency of feeding; this, however, proved fruitless. The bulkiness and the very low energy value of the traditional foods meant that no overall increase in the daily energy intake was possible using these foods. Although high-energy weaning foods were clearly called for, it was shown that breast milk, at 70 kcal/100 mL, has twice the energy density of the weaning porridges common in this region. Rutishauser concluded that this high-energy breast milk was essential to good growth.

A significant difference in energy consumption was found during the 2nd year of life between breastfed and nonbreastfed children. Breastfed children aged 13-18 months received 25% more energy than those who were not breastfed. Among older children, the consumption of energy was 17% higher for those who were breastfed than for those who were not. Rutishauser also found that even after breastfeeding had stopped, and the intake of other food had increased by 60%, this was insufficient to make up for the energy previously supplied by breast milk, leaving the nonbreastfed child with an energy deficit of 28% (Table 1).

A similar relationship between energy intake and continued breastfeeding was found in Machakos, Kenya, particularly from the ages of 18-23 months (van Steenbergen 1981). Those infants who were breastfeeding had 108% of recommended daily calorie intake (RI), compared with 84% of RI in the nonbreastfed group. Other variables did not show any definite association with the child's energy intake: those variables included source of major foods consumed (whether purchased or home produced), size of household, sex of child, presence or absence of father, marital status of mother, and percentage of time spent at home. On the other hand, there was clearly a relationship between energy intake and breastfeeding. This study also found that

Table 1. Energy intake (%) of children breastfeeding or not breastfeeding in 2nd year.

	Breastfeeding	Not breastfeeding
Breast milk	53	-
Cow's milk	5	13
Sugar and cereals	7	14
Staples	20	26
Other foods	15	19
Energy deficit	-	28

Source: Rutishauser (1974).

breast milk could provide almost 50% of caloric RI for infants of 7-18 months, and more than 10% of RI for infants of 19-36 months (van Steenbergen et al. 1984).

According to Behar (1986), "particular attention should be given to proteins, iron, and vitamins A and C, nutrients that are frequently found to be deficient in the diet of young infants." Continued breastfeeding provides important amounts of all these critical nutrients. Using figures for recommended intake from Cameron and Hofvander (1983), we find that a child of 1-2 years would receive the following percentages of his or her needs from 500 mL of breast milk: energy, 31; protein, 38; vitamin A, 100; vitamin C, 95; calcium, 44.

Protein

There is some variation in protein levels in breast milk from one time of day to another, from the beginning of a feed to the end of the feed, and from one mother to another. Perhaps the most dramatic change appears in the reduction, as breastfeeding progresses, of the high protein levels in colostrum. An approximate protein figure that has been widely used is 1.07 g/100 mL (Cameron and Hofvander 1983). It should be noted that the protein in breast milk is considered a reference protein; few other dietary sources are so well absorbed (Helsing and King 1982).

Studies of protein in extended lactation are few, but researchers in Côte d'Ivoire found that, after an initial drop from higher levels, a fairly steady level was reached at 0.96 g/100 mL over 23 months of breastfeeding. This level was comparable to that found in studies carried out in Ethiopia, Nigeria, and Zaire; Lauber and Reinhardt (1979) concluded that composition both in proteins and in lipids "remained virtually constant over 23 months of lactation."

In examining Ugandan breastfed children receiving supplementary foods, Rutishauser and Whitehead (1972) found a mean daily protein intake of 2.2 g/kg of body weight during the 2nd year. In Machakos, Kenya, children of 13-18 months were taking 2.2 g of protein/kg of body weight from breast milk and from other sources. The protein contributed by breast milk at this age ranged from a mean of 4.25 g/day during the lean season to 5.0 g during the harvest season (van Steenbergen 1984).

Iron

Like other milks, breast milk is not rich in iron. Values for iron in breast milk vary from 0.8 mg/L (Cameron and Hofvander 1983) to 1.0 mg/L (Lawrence 1985) to 2.0 mg/L (Latham 1979). Iron deficiency anemia is rare in young, exclusively breastfed babies. Epidemiological studies have not yet been undertaken, however, to compare anemia rates of substantially breastfed and nonbreastfed children aged 1-2 years in developing countries.

The iron in breast milk is 49% absorbed, a far better absorption than from most other dietary sources (McMillan et al. 1976; Lawrence 1985). It is hypothesized that many elements in human milk, including vitamin C and lactose, enhance iron absorption, and that the folic acid, vitamin E, and copper in breast milk also help to prevent anemia (LLLI 1975).

If we take Latham's figures for iron content, 500 mL of breast milk contains 1 mg of iron. Absorption of 49% of this amount would provide about 50% of the daily requirement of absorbed iron for children of 1-2 years. The usual 10 mg recommended intake presumes that only 10% (i.e., 1 mg) will actually be absorbed.

Vitamin A

Amounts of vitamin A in breast milk may vary with a mother's intake, and may decrease somewhat with extended lactation (Anon. 1985). Breast milk is nevertheless an excellent source of this vitamin (Berg and Brems 1986). If vitamin A levels in the mother are low, an oral supplement of 200,000 IU every 4-6 months is recommended. A volume of 500 mL of breast milk gives 100% of the daily requirement in the 2nd year of life.

Breast milk protects babies against xerophthalmia, even if maternal vitamin A levels are not optimal. As was stated in Dialogue on Diarrhoea (Anon. 1985): "Even without vitamin A supplementation of the mother, the risk of xerophthalmia for children under two who are not breastfed is nevertheless six to eight times greater than for those receiving breast milk."

If the breastfeeding is substantial and prolonged, then the protection provided by it lasts beyond its cessation. West et al. (1986) showed lower risk of xerophthalmia from ages 2-6 years among children in Malawi who had been exclusively breastfed for longer, and who had had a longer weaning interval. Children presenting with xerophthalmia between 24 and 47 months were more than three times as likely to have stopped breastfeeding before 24 months, compared with children who had no xerophthalmia.

Vitamin C

A daily volume of 500 mL of breast milk provides 19 mg of vitamin C, 95% of the amount that children need in the 2nd year. Weaning recommendations that ask parents to buy citrus fruits and vitamin C drinks are unnecessary for substantially breastfeeding children. Studies in Finland (Salmenpera 1984) show that vitamin C concentration in breast milk at 12 months is 3.3 times the mother's plasma level. In these studies, exclusively breastfed babies had better vitamin C levels at 12 months (mean 1.43 mg/100 mL serum) than did babies fed on vitamin C-fortified formula, fruits, and vegetables (mean, 1.02 mg/100 mL). If the mother had a subnormal plasma level of vitamin C (0.6 mg/100 mL), the infant usually had a plasma concentration 6-12 times that of the mother, showing that maternal plasma concentrations had only a marginal effect on infant plasma levels.

Karra et al. (1986) found that vitamin C plasma-milk ratios increased from 1-6 months, and then remained steady through 24 months of lactation. Subjects in the study went from a mean of 5.5 breast feeds/day (substantial breastfeeding) at 7 months to a mean of 1.5 breast feeds/day at 24 months. Vitamin C levels increased in some mothers' milk during the last 2 months of breastfeeding, suggesting that levels of specific nutrients may be affected by the token breastfeeding pattern.

The Malnourished Breastfeeding Child

With all the nutritional benefits of prolonged breastfeeding, why do some studies find an association between long breastfeeding duration and malnutrition? Victora et al. (1984) found in Brazil that children who were breastfed past 12 months showed a higher rate of malnutrition. In Kenya, children breastfed beyond 16 months have also shown higher rates of malnutrition than those off the breast, whereas those who are breastfed up to 15 months have shown an advantage over those not being breastfed (Kenya 1984).

These studies have not, however, collected data on the frequency of breast feeds, on the overall breastfeeding pattern, or on the volume of breast milk taken. They have not looked at the adequacy of other foods given to the child, nor have they corrected for socioeconomic and other factors. It may be that women tend to go on breastfeeding when, for economic or other reasons, they have little else to offer their child, so that supplementation is delayed or minimal. A study of the Kenya Central Bureau of Statistics (Kenya 1977) concluded that "breastfeeding itself is not at fault, and makes a positive contribution to the diet."

Johnson and Zeitlin (1984) in Mexico found another possible factor. Mothers distracted by many responsibilities would reach a point of impatience with breastfeeding and with any other feeding that required their personal attention. In some cases, the mother would bond preferentially with one child and neglect another. Under these circumstances, only those children who were able to feed themselves would get enough to eat, and those still depending on the breast would receive only token feeds.

Breast Milk and Illness

Protective Value

Breast milk contains protective factors unavailable from any other source. These are adapted to the child's needs and to the stage of lactation. A child off the breast may become ill and stay ill longer, not in all cases because the mother is preparing other milks carelessly, but often because those substitutes are completely unable to protect the child during the vulnerable period from birth to 2 years. Studies in industrialized countries show higher rates of illness in babies off the breast, even when those babies are fed on clean formulas (Cunningham 1977; Koopman et al. 1985).

Human milk contains living cells, both macrophages and lymphocytes, and also carries various protective humoral factors: there is one that promotes the growth of Lactobacillus bifidus in the gut, a staphylococcal resistance factor, interferon, lactoferrin (which inhibits growth of Escherchia coli by binding iron), and lysozyme, which acts against intestinal bacteria. Lysozyme, a nonspecific antimicrobial factor, is highly concentrated in milk, compared with maternal serum values. Lysozyme levels rise from the 2nd month of lactation, in some samples reaching levels exceeding those in colostrum at about 12 months (Peitersen et al. 1975). Goldman et al. (1983) found first a rise in lysozyme levels, from 12-25 months, and then a fall; they found a continuing rise in levels of lactoferrin. Clearly, more investigation is needed in this area.

Mother's milk also provides the baby with all classes of immunoglobulins, especially IgA. Early studies of these showed a high level in colostrum, falling off sharply in the first 15 days and then declining more slowly to the age of 16 months. When breast milk studies were limited to the first 6 months, it was reasonable to assume that the protection afforded by mother's milk in breastfeeding of longer duration must be negligible. Later studies of prolonged lactation showed, however, that immunoglobulin levels increased from 6 months onward, apparently in response to the decreasing volumes of milk produced. At about 20 months, IgA and IgG approached the levels found in the 2nd week postpartum (Peitersen et al. 1975).

Antibodies in breast milk are specifically adapted to the child's needs for protection. A mother exposed to infection via the gastrointestinal tract or the respiratory tract will show in her breast milk secreted antibodies specific to that infection (Minchin 1985). During the breastfeeding period, there exists a mother-child bond that is not only emotional but also immunological.

Diarrheal Diseases

Continued breastfeeding may contribute significantly to preventing diarrheal diseases at every economic level. Feachem and Koblinsky (1984), analyzing 35 studies of diarrhea morbidity, concluded that "the data ... gave no grounds for supposing that the relative risks of diarrhoea for bottle fed infants are lower in more wealthy families."

In many studies, however, it has not been shown that breastfeeding plays a protective role after the first 12 months; indeed, some studies correlate prolonged breastfeeding with slightly increased rates of diarrhea. Like the nutrition studies, however, these studies do not distinguish substantial from token breastfeeding, nor do they control for other factors such as amount of breast milk taken, amount and suitability of supplemental foods, adequacy of growth pattern, concurrent infections, maternal education, and household sanitation.

Other studies have indeed found that prolonged breastfeeding plays a protective role. Clemens et al. (1986) state: "The high degree of protection against severe shigellosis was evident for breastfed children up to 35 months of age." Le Page et al. (1981), in a hospital-based study of 2339 children in Kigali, Rwanda, concluded that the protective effect of breastfeeding is not limited to the 1st year. For three disease categories, case fatality rates were significantly lower in breastfed children than in those completely off the breast: these categories were measles, diarrheal diseases, and acute lower respiratory infections. This advantage was observed for all age groups studied, including children up to 24 months.

When diarrhea does occur, breastfeeding is also an essential element in oral rehydration therapy (Tripp et al. 1979; Khin-Maung-U et al. 1985). Reestablishment of substantial lactation was incorporated into diarrheal management during the 1960s at Mulago Hospital, Kampala (Jelliffe and Jelliffe 1978), and in Nairobi during the 1980s (J. Turkish, personal communication). This, however, is not yet a universal practice: in some communities of our region, breastfeeding when a child is ill or has diarrhea may not be culturally accepted; it may also be prevented by hospital practices that exclude mothers from pediatric units except at limited visiting hours.

Because breast milk production depends on sucking stimulation, hospitals that insist on withdrawing breast milk from sick children may not only delay the child's recovery, but may also cause the mother's milk to dry up. In Mauritius, Rajcoomar and Wong (1986) found that 7% of women who had stopped breastfeeding had done so because their babies were sick, and 25% of these had been advised to stop by health professionals. If breastfeeding is interrupted by a child's illness, especially if it is stopped every time that diarrhea occurs, there will soon be much less of this important food available for the child when he or she is most vulnerable (Anon. 1983).

Roy et al. (1984) are among those researchers who have verified that, with substantial continued breastfeeding (about 600 mL/day) during oral rehydration therapy, no additional water is needed by children aged 12-17 months. Nutritionists are aware, as many health workers may not be, that every water feed from birth onward displaces a more nourishing feed that contains nutrients needed for growth. During diarrheal illnesses, feeding with water instead of with nutrient-rich breast milk may lead to greater weight loss than is necessary.

Anorexia

Anorexia may contribute to negative outcomes of relatively mild diseases. A sick child, however, will still seek comfort at the mother's breast, even when he or she cannot be tempted by any other foods (Brewster 1979; Bumgarner 1980). If not impeded, sick children will usually increase their breastfeeding frequency, thus increasing the mother's production of breast milk. Hospitalized children allowed to breastfeed on demand day and night will stimulate ample milk secretion with frequent suckling. If all pediatric facilities urged mothers to be present around the clock and to breastfeed whenever they wished, there might well be a significant lessening of illness-related weight loss, of its attendant anorexia, and of the subsequent need for major "catch-up" growth. In these settings, however, mothers are, at present, rarely told of the protective and curative effects of breast milk, or informed about the process of reestablishing substantial lactation.

A study by Hoyle et al. (1980) in Bangladesh compared the normal dietary intake of children aged 6-35 months with that of a matched group who were hospitalized with diarrhea. Overall, the energy intake of the ill children decreased by 40%. Among those who were substantially breastfed (average frequency, 11 times/day), the energy intake from breast milk showed little decrease. Breast milk provided 62-81% of the ill children's caloric intake, the higher figure relating to those mothers who had been educated by staff as to the increased nutritional needs of children with diarrhea. Although a specially prepared weaning food of local ingredients was served (rice, "dhal," pumpkin, sugar, and oil), the continued breastfeeding contributed 2.5 times as much protein to the ill children.

It was concluded that during acute episodes of diarrhea, continued substantial breastfeeding afforded protection to a child against reductions in caloric and protein intake, and confirmed that anorexic children will accept fluid in the form of breast milk. A later study also demonstrated that breastfeeding during diarrhea reduces the number and volume of diarrheal stools (Khin-Maung-U et al. 1985). Rohde (1974) points out also that the high-quality protein taken in from breast milk by an anorexic child may help to restore appetite for needed carbohydrate foods.

Especially in communities where breast milk is the young child's principal reliable source of energy and high-quality protein, continued breastfeeding throughout the 2nd year contributes to illness prevention and treatment. Even if breastfeeding has been reduced to token levels of once or twice a day, the informed mother can reestablish an ample flow when motivated by the knowledge that this has enormous value for her child's recovery, and when encouraged by appropriate hospital management practices.

Fertility Regulation

It is now clearly recognized that breastfeeding, by extending the postpartum anovulatory period, makes a significant contribution to birth spacing and fertility regulation. The increasing of birth intervals has important positive consequences for maternal health, and for child health and development. Breastfeeding - a cost-free, universally available, and natural method of birth spacing - is responsible for "more spacing of pregnancies than any other currently available technique or method" (Carballo and Marin-Lira 1984).

The decline in breastfeeding durations found in many developing countries, especially among urban populations, has enormous consequences in terms of increased maternal fertility (Lesthaeghe et al. 1981; McCann et al. 1981; Mosley et al. 1982; Short 1984). Were periods of lactational amenorrhea to drop, a vast increase in contraceptive use would be needed to keep fertility at its present level in many developing countries (McCann et al. 1981). In Bangladesh and Kenya, for example, dramatic changes in contraceptive practice would be necessary to offset the effects of a decline in breastfeeding. Should postpartum amenorrhea decline to a 2-month period, a 25% increase in fertility rates in Kenya would result (Mosley et al. 1982).

Studies exploring the relationship between breastfeeding patterns and amenorrhea have demonstrated that frequency of suckling, the giving of night-time breast feeds, and the timing of supplementation were the most important factors affecting the maintenance of amenorrhea (Gross and Eastman 1985; Elias 1986; Huffman 1986). According to the WHO (1981) study, 85% of variability in the return of menstruation was attributed to differences in breastfeeding behaviour. Among women in rural Bangladesh, Huffman et al. (1980) found that during the 2nd year postpartum, the number of breast feeds in an 8-h period was maintained at five or six. These women breastfed for more than 2 years, slept with their children at night, and supplemented the breast milk, generally after an initial 6 months of exclusive breastfeeding; they experienced amenorrhea of up to 20 months.

Similarly, in Zaire, where on average women breastfeed more than 2 years, Huffman (1986) found that only 10% of those whose babies sucked more than 10 times per day showed signs of ovulation. It has also been suggested that the length of the longest interval between breast feeds (for example, during sleeping hours or during periods when the mother is separated from the baby) may be an important variable directly affecting the duration of amenorrhea (Greiner 1985).

During amenorrhea, the risk of conception is greatly decreased. About 2-8% of lactating, amenorrheic, noncontracepting women will conceive, demonstrating that lactation protection is as effective as other contraceptive methods used in developing countries (Short 1984; Greiner 1985).

The significance of breastfeeding in delaying pregnancy is greatest where other methods are not widely accepted as, for example, in Kenya and Zaire. In Zaire, at 12-17 months postpartum, up to 60% of nonbreastfeeding women were pregnant, in contrast with only 5% of their breastfeeding counterparts (WHO 1981).

Although the effect of breastfeeding on fertility levels is substantial, few family-planning programs now teach mothers how to use breastfeeding to enhance their protection against a new pregnancy. Such emphasis on teaching women the use of breastfeeding as a contraceptive measure is especially important in cultures where only natural family-planning measures are acceptable, and in areas with high discontinuation rates or low acceptance rates for other methods of contraception.

Emotional and Social Development

Prolonged breastfeeding may improve the child's psychosocial development. For the mother whose work takes her away from the child for long periods each day (e.g., the typical African woman), breastfeeding keeps her in closer touch with the child. Working mothers in other societies have stated this to be an important reason for continuing breastfeeding (Bumgarner 1980).

Reamer and Sugarman (1987) report that North American mothers who breastfed an average of 18 months (much longer than usual in that culture) felt that their children were more secure emotionally and had warmer personalities than might otherwise have been the case. The mothers themselves felt that the mother-child bond was strengthened by prolonged breastfeeding. According to these mothers, the principal drawback was criticism by other people. Our experience suggests that such negative community opinions about prolonged breastfeeding may be a factor of increasing significance in the trend toward early cessation in urban Africa.

If breastfeeding in the 2nd year does enhance bonding, the mother's attentiveness to her child and to its health may also be improved. Dettwyler (1986) in Mali established a connection between the growth and health of children and their mother's attitude toward feeding them and seeking health care. Researchers found that it was not the variable of socioeconomic status that correlated with good growth and health, but rather "above average maternal attitude." The culture studied is characterized by prolonged breastfeeding of all children, but those children in the higher weight group were breastfed about 2 months longer than those in the low weight group, and were more likely to have "above average attitude" mothers. Johnson and Zeitlin (1984) found in Mexico that, on the one hand, children showing good growth had caretakers of whom 85% were attentive; on the other hand, those children with poor growth had caretakers of whom only 40% paid much attention to their charges. These results suggest a line of inquiry that might reward research in other African communities.

Most child specialists agree that the soundest development proceeds at the child's own pace. Because every child as it grows will sooner or later lose interest in breastfeeding, a practice of gradual weaning may be psychologically beneficial. Traumatic or forced cessation has been associated with anorexia, illness, and regression. It may be even more damaging if the child is sent away from his or her parents, or is stopped from breastfeeding by a hospital stay (Bowlby 1969).

Some mothers and health workers fear that so long as children are still breastfeeding, they will not eat sufficient amounts of other foods. This can be the case where the mother's only close contact with her child is during breastfeeds. Giving ample attention to the child in nonfeeding contexts will, however, build an emotional rapport that permits the child gradually to relinquish the breast without fearing a loss of contact with the mother.

Discussion

Breastfeeding should be considered an essential part of the diet for at least the first 2 years. Breast milk is a vital national food resource, produced at the household level, perfectly stored, and specifically targeted at small children in their vulnerable first years. Because prolonged breastfeeding is a valuable practice, it should not go unrecognized and unrewarded.

To advise mothers to "breastfeed as long as possible" is to give inadequate guidance to parents and health workers. National nutritional plans should include specific targets for breastfeeding patterns, stipulating the ideal number of months for exclusive breastfeeding and for substantial breastfeeding (including night feeding), and a minimum age for the cessation of breastfeeding.

Food-intake recommendations of WHO and the Food and Agriculture Organization (FAO) of the United Nations still advise additional food for mothers only during the first 6 months of lactation (WHO/FAO 1976). After that, the nutritional requirements of continued breastfeeding are discounted. If the mother does breastfeed for another 18 months, she will do so with no assistance from present WHO nutritional guidelines or from food policies based upon them.

In the absence of strong health-education measures, improving the overall food supply will not necessarily improve breastfeeding performance. The breastfeeding pattern of well-nourished urban women, for example, is adversely affected by commercial company advertising, growing customs of mother-baby separation, and possibly societal disapproval of breastfeeding beyond 1 year. Health education that ignores breast milk as a component of the young child's diet may also discourage continued breastfeeding. There are very few nutrition posters that show the older child breastfeeding in the sitting-up position typical of the walking child. There is a greater need for such posters in national health education campaigns, than for posters showing the breastfeeding of newborns.

Multinational companies are now producing more "weaning" products. Both mothers and health workers are deluged with messages suggesting that the child at 6 months or older must have commercial products or suffer a weaning diet that is incomplete and dangerous. Usually such promotion makes no mention at all of breast milk, but urges the use of some form of cow's milk. Strong codes are needed to eliminate such marketing.

Women whose work separates them from their children are of special concern to health and nutrition policymakers. Longer postpartum maternity leaves are extremely important for establishing breastfeeding. To ensure, however, that breastfeeding extends to 2 years, other policy measures are needed. These include

- support for breastfeeding at the workplace and in the community;
- continued flexible breastfeeding breaks;
- flexible working hours for breastfeeding mothers and no extraordinarily long working hours, as in night-nursing duty;
- education on the value and importance of continued, unrestricted night feeds and close physical contact;
- feeding of the child during the mother's absence without any use of feeding bottles: milk can be given from a cup to any baby weighing more than 2 kg (IBFAN Africa and UNICEF 1986);
- where feasible, workplace care facilities for young children;
- when necessary, nutritional supplementation programs for mothers; and
- access for every woman to effective and acceptable family-planning methods that are fully compatible with extended substantial lactation.

Where, then, does breast milk fit into the weaning diet? As health educators, we need to emphasize that food supplements are not substitutes for breastfeeding. Provision of supplementary foods should not lead immediately to token breastfeeding. Weaning programs have often recommended large quantities of fairly liquid food for small children. The Kenya Ministry of Health (Kenya 1986) suggests 900 mL of porridge per day for children 6-12 months. For corrective nutritional programs, OXFAM (1984) recommends 1500 mL/day of high-energy milk for malnourished children weighing 7.5-10.0 kg. Yet these programs also rightly stress the importance of continued breastfeeding and, when necessary, the reestablishment of lactation. This fluid-intake recommendation may be unrealistic for the small child. Will a baby want 500 mL or more of breast milk in addition to these large quantities of other liquid? Foods that are drier may make the child somewhat thirsty, encouraging him or her to seek a drink from the breast at more frequent intervals and thus promoting continued or reestablished substantial lactation.

When a busy mother sits down to eat her meal, it may be the first time in some hours that there is sufficient quiet to allow a breast feed. To breastfeed when the rest of the family are eating may mean, however, that the young child is not likely to get much, if any, of the family pot food: at the time when this food is available, the child is filling up with breast milk. One suggested routine is that the mother breastfeed before preparing the meal, then encourage the child to eat foods with the rest of the family, then breastfeed again after the meal.

Will the feeding mixtures we recommend require more attention from the mother than she can spare? Because they do not need to be served warm or to be spoonfed, meals of cassava and sauce, bread and margarine, fried staple foods, or chapatis cooked with oil might give the child a greater net intake. Is it wise, therefore, to advocate many months of feeding with thin porridge? What is the best use of a mother's limited time with her child - breastfeeding, feeding with thin porridge, or feeding mashed family pot foods? The answers change as the child grows; in most African situations, however, a mother has many claims on her time. We should perhaps advocate the occasional use of other foods - cold rather than freshly cooked - that 1-year-olds can easily feed themselves; this would supplement the breast milk that mothers can give whenever they have a quiet 5 minutes to spare.

Promotion of extended breastfeeding deserves effective incorporation into all child-survival strategies. No immunization program is complete unless it teaches all mothers that only breastfeeding can protect their babies against the gastroenteritis and respiratory infections for which no injections are available. Growth monitoring programs can give reassurance to mothers who, without justification, fear that they have insufficient milk. If growth falters, health workers can be alerted to teach a more effective breastfeeding pattern and to follow up on the mothers' progress. Unless they stress diarrhea prevention through more substantial breastfeeding, and diarrhea treatment through increasing breast-milk intake, oral rehydration efforts will be incomplete. Feeding programs need to teach and to reinforce substantial breastfeeding patterns during the weaning interval. If family-planning programs mention breastfeeding (either positively or negatively) without teaching those breastfeeding patterns that can inhibit ovulation, then they do a disservice to millions of Roman Catholic, Islamic, and other women who will not use alternative contraceptive methods.

Too many children under 2 years are taken off the breast because of illness or diarrhea, especially when treated in an institution. Too many feeding programs distribute powdered milks, instead of reestablishing substantial breastfeeding. National reeducation programs are needed to familiarize nutritionists and health workers with the techniques of breastfeeding maintenance and of relactation; this knowledge can then be incorporated into hospital, outpatient, and nutrition-rehabilitation programs.

Maternal education tends to improve child-survival statistics (UNICEF 1985). In Africa, however, it also seems to contribute to declines in breastfeeding rates and durations. The education system, its teachers, and its domestic science and health textbooks may in some way be encouraging girls to reject practices not presented as "modern," thus creating patterns of poor infant feeding for the future. Many texts include lessons on the use of feeding bottles, while giving no information on prolonged breastfeeding, or on cup-feeding by employed mothers (BIG 1985). It is important to consider what aspects of the educational environment may influence pupils' later decisions about infant feeding.

Despite disincentives, a great deal of breast milk is fed to the children of this region well beyond the age of 1 year. Research should reflect the importance of breastfeeding throughout the first 24 months: to this end, there should be a painstaking examination of breastfeeding patterns, and of levels of breast milk intake and of total energy intake during the weaning period. Researchers must go beyond the simple question "Are you breastfeeding?" to record frequency and length of feeds, both day and night, and intervals between them. As van Steenbergen (1981) demonstrated, it is possible in African home settings to gather milk-volume data on demand feeding for both day and night. Extrapolating 24-h volumes from partial measurements is not acceptable methodology, given the probable diurnal variations in breastfeeding behaviour. As they are surrounded by communities where the majority of women practice prolonged breastfeeding, researchers in Africa are exceptionally well placed to undertake the fundamental studies needed.

Much remains to be done to ensure that breast milk retains its important place in the diet of the young child. There can be no justification for accepting breastfeeding declines as inevitable, particularly as rates rise dramatically in other countries. Breastfeeding should be promoted, protected, and assisted, not only in the early months of life, but throughout the 2nd and even 3rd years. It should be understood and valued for the unique contribution it makes to the nutrition, health, and well-being of every child, rural or urban. Our attitudes, policies, training for health workers, and contacts with families should now begin to reflect this understanding.

Recommendations

- Governments should consider positive incentives to reward women who breastfeed for 2 years.

- National health policymakers should set targets for the duration of breastfeeding, and should recommend appropriate breastfeeding patterns for each age group.
- Tables of nutrient requirements should stipulate recommended intakes for lactation up to 2 years.
- Education directed either at parents or at health workers should promote breastfeeding as a vital component of the diet of the 2nd year. The importance of appropriate breastfeeding patterns should be emphasized.
- A national code of marketing should be adopted and enforced by each country. These codes should include in their scope all food and drink products for children of 2 years or under.
- Employed women need government support and education to continue substantial breastfeeding and to reject the idea of bottle feeds.
- There should be an investigation into the reduced use of liquid weaning foods: the less liquid consumed by the child, the greater will be his or her interest in frequent breastfeeding.
- Frequent breastfeeding should be encouraged for the child of 1-2 years; it should be emphasized, however, that these feeds take place at times that do not interfere with the child's interest in the family pot food.
- Programs should recognize the constraints on women's time and adapt their recommendations to these limits.
- In teaching exclusive, substantial, and prolonged breastfeeding, all child-survival programs should emphasize both the appropriateness and the cost-free nature of these techniques.
- Nutrition-rehabilitation centres, diarrheal-control programs, and hospitals should incorporate modern breastfeeding management and relactation into all programs for children under 2 years.
- For the assurance of health protection for children yet unborn, information on nutrition must be incorporated into the formal education of all young people: texts should contain accurate information on prolonged breastfeeding and on good child nutrition.
- Appropriate research, using sound methodology, should be undertaken on breastfeeding for the entire weaning period.

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THE COMPLEMENTARY FOODS PROBLEM

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Abstract *In this paper, an attempt is made to distinguish the term "weaning" from the related processes of "complementation" and "sevrage," or cessation of breastfeeding. In the feeding of young children in rural Africa, it is not the "weaning problem" but rather the problem of complementation that should be of primary concern. Although recognizing the importance of complementary foods in infant feeding, this paper discusses the dangers that arise from an improper administering of these foods, and warns against an overly zealous promotion of the new technologies discussed at the workshop.*

Most nutritionists would agree to an approximate definition of the term "weaning" as "the process of replacing breast milk with other foods." The word is commonly used, however, to suggest two additional processes: the complementation of full breastfeeding with other foods, and the complete cessation of breastfeeding. (Some use the French word "sevrage" to denote this latter process.) The word "wean" is thus misused, perhaps because of the convenience of its compound forms, i.e., "weaning age child" and "weaning foods problem." Serious errors in health policy and practice result, however, from such inaccurate use of terminology: a lack of clarity here can have the effect of hiding or confusing the true causes of problems in nutrition.

To illustrate the definitional issues involved, let me take the example of energy requirement. One must compare the child's increasing nutrient needs with the mother's ability to produce breast milk (Fig. 1). In this figure, no numbers have been placed on either axis: such numbers are not needed to illustrate the principles concerned.

One curve illustrates the way in which the child's energy needs increase with age. The shape is not important, except insofar as the curve rises with age while its slope declines. A second curve illustrates the change in the amount of milk the mother can produce as the child's age increases. Under normal circumstances, the two curves tend to follow each other rather closely for a matter of months. At some point, this ceases to be true, as the child's energy needs outstrip milk production.

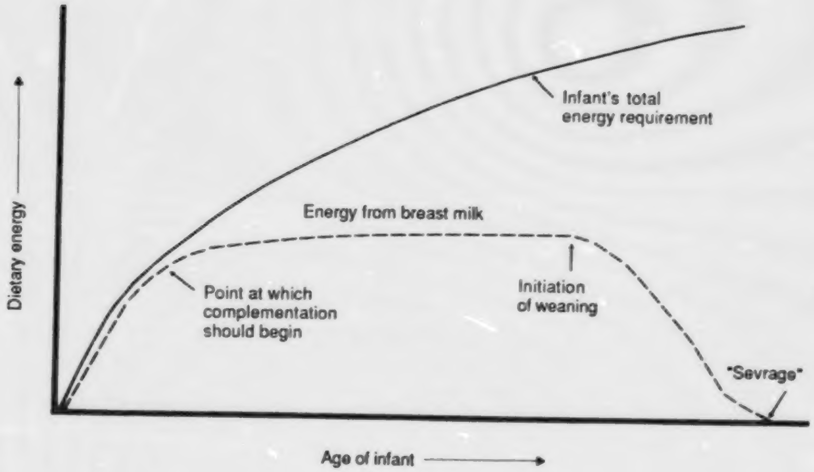

Fig. 1. Relationship over time between an infant's total energy requirement and optimal breast-milk consumption.

At this point, the child will decrease his or her activity level, cease to grow as fast, or both, unless some additional source of energy is provided. It is important to recognize that the food providing this energy need not replace breast milk. Studies in the Gambia showed that, as long as this additional food - let us call it "complementary food" - is kept in short enough supply, the child continues to suck the breast as much as before, and the hormonal system that adjusts breast milk production to match demand remains relatively undisturbed. If the amount of food assimilated by the child continues to increase at the same pace as his or her energy needs, then breast milk production stabilizes near the maximum level that the mother is able to produce.

At some later point, the mother can reduce this level of breast milk production by allowing less sucking, offering more food, or both. This may or may not be to wean the child away from the breast: she may, for example, simply wish to spend less time with the child. Of course, reduced breast milk production will always result from a reduction in sucking, irrespective of any conscious decision. Eventually, however, the decision to wean must be made and it is at this point that the weaning process truly begins. In rural Africa, a delay in the initiation of weaning has many advantages, the two most important of which are

- the likelihood that continued breastfeeding will lengthen the period of lactation amenorrhea and thus assist with birth spacing; and

- the likelihood that the nutritive value of breast milk will be greater than that of the food that replaces it.

The weaning process can proceed gradually or take place abruptly, as the mother and child like. Extremes at either end of the spectrum appear to be fairly common. A problem develops only when weaning takes place too abruptly for adaptation on the part of the child; in such a case, he or she may not be able to eat replacement foods of adequate nutritional value. This can be said to be a true "weaning foods problem," and its importance has been recognized for many decades in pediatric and nutrition literature.

When, however, a child of 2-3 years is abruptly weaned, this does not constitute a "weaning foods problem": by this age, the child is able and willing to eat the family food. No doubt this food often does not meet ideal nutritional standards for a child of that age; the really severe problems occur earlier, however, before the child is old enough to eat thick porridge and other family foods. When referring to this earlier period, it would be more appropriate to speak of a "complementary foods problem."

In some rural areas, particularly in South Asia, complementation begins too late and the amounts given are too small. The gradual undernutrition that results has received a great deal of attention. In other areas - in much of Indonesia, for example - complementation with "soft foods" begins far too early. It is difficult to generalize about Africa: although one can find either extreme, most mothers do seem to begin "solid feeding" between 3 and 9 months of age.

As development takes place, however, it brings with it an increase in the availability of feeding bottles; the dangers of premature supplementation then become of greater importance to public health. These dangers have received far too little attention: the importance of early complementation (at 4-6 months of age) is often stressed in health-worker training and in health-education messages; rarely, however, are warnings issued against a precipitate or excessive provision of complementary food.

When complementary food is given to the child before his or her needs exceed the mother's breast-milk production, the child will suck less at the breast; in this way, the additional food replaces rather than complements breast milk. The nutritional quality of the child's diet is thus lowered, and he or she may be confronted with diarrheal and other pathogens before the immune system is ready to cope with them. Premature supplementation also has a drastic effect on lactation amenorrhea (McCann et al. 1981) and, consequently, on birth spacing. Because of the child's innate need for a certain amount of sucking, the use of feeding bottles may have an especially deleterious effect.

Data from the Yemen Arab Republic (Yemen 1980) illustrate the effect of a radical and rapid increase in premature supplementation. Although, on average, rural children are still breastfed for 1 year, they begin to receive bottle feeds at a median age of 2 months (Greiner 1983). Since only about 2% of couples use any form of modern contraception (Suchindran and Adlakha 1979), birth spacing has been drastically affected: many women now have a child every year or 18 months. The bottle-fed Yemeni child, therefore, has not only to survive his or her poor and probably contaminated diet in the early months of life; while still too young to eat family foods, this child must also survive the complete withdrawal of the breast when the

Table 1. Infant and young-child mortality rates in the Yemen in relation to birth spacing.

Length of the preceding birth interval (months)	IMR[a]	YCMR[b]
< 24	227	141
24-35	109	18
36-59	83	2
> 59	56	3

[a] Infant mortality rate: number of deaths under 1 year of age per 1000 live births.

[b] Young child mortality rate: number of deaths among children between 1 and 5 years of age per 1000 children of that age.

mother all too soon becomes pregnant again; several months later, the child will have to survive the third blow, when much of the mother's attention is withdrawn in favour of the newborn.

Tragically, many of these children do not survive. In a country with moderately high, well-distributed incomes, the infant mortality rate is 157/1000, and the young child mortality rate is 95/1000 (Suchindran and Adlakha 1979). The interrelation between these mortality rates and degrees of birth spacing is telling (Table 1). The fact should be noted that the effect on young child mortality is even greater than that on infant mortality: it would be fair to say that were they able to practice birth spacing, Yemeni women would be able to keep their young children alive. In the absence of modern contraception, this adequacy of birth spacing is largely dependent on the continuance and the preponderance of breastfeeding in the child's regimen.

In conclusion, it would seem that our challenge is to assist mothers to feed the "complementation-age" child adequately. This necessitates a provision of the correct amount of complementary food at the correct time. In our enthusiasm for the new technologies discussed at this workshop, we dare not cause in Africa a tragedy similar to that taking place in the Yemen.

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SORGHUM AND MILLETS IN EAST AFRICA WITH REFERENCE TO THEIR USE IN WEANING FOODS

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Abstract *In sub-Saharan Africa, millions of children are given sorghum and millet as weaning foods. Although lysine has been found to be a limiting amino acid, the problem of protein digestibility can be alleviated by the use of a legume with the sorghum in weaning-food preparations. This technique offers a solution to the problem of "bulkiness" common to sorghum and millet weaning foods: the use of only 5% malted flour (from finger millet) has proved a simple yet efficient method of reducing viscosity; by allowing, moreover, for the addition of twice the normal amount of flour, this technique has the effect of increasing the energy density of the food. Nutrition campaigns, especially those in Tanzania, have provided good opportunities for the promotion of "power flour" (P.F.) or "kimea." The Iringa Nutrition Programme has shown that moderate and even severe protein energy malnutrition (PEM) could be reduced in sorghum-dominated areas as much as in maize-dominated areas. The introduction of affordable technology, such as sorghum dehullers and hand mills, has a positive impact on the utilization of sorghum and millets; this technology appears, moreover, to reduce the workload of women.*

Food is an essential component of nutrition; food production in Africa, however, is on the decline. In sub-Saharan Africa, daily food intake per capita has decreased from 2109 kcal in 1961 to 2097 kcal in 1984. Persistent drought, frequent famines, and misdirected policies all have adversely affected the traditional food systems in many countries in Africa. Despite being the "home" for sorghum and millets, sub-Saharan Africa is able to produce an average yield of only 0.5 t/ha - a figure that appears embarrassingly low when compared with the 3.0 t/ha or more produced in other countries. In 1984, about 140 million (of Africa's total population of 531 million) were fed with grain - maize, wheat, and rice - imported from other countries. By the year 2025, the population in Africa will probably triple to 1.5 billion; the chronic decline in the production of cereal grains is therefore a cause for serious concern.

The number of malnourished people in Africa has risen, since 1980, from 80 to 100 million. The worst affected are children under

5 years of age. Of a global estimate of 575 million children under 5 years of age in 1986, nearly 14 million died because of malnutrition, diseases, and inadequate health facilities; over 4 million (30.9%) of these young-child deaths were in Africa. Of the children alive today, more than 40% suffer from moderate malnutrition and 8-10% from severe protein energy malnutrition (PEM). According to 1986 estimates, most countries with "very high" (more than 175) and "high" (95-174) mortality rates for children under 5 years are in Africa. In East Africa, it has been observed that most young-child deaths occur during the 1st year of life. The period during which undernourishment is most likely to take place is between 4 and 6 months. For normal growth, an infant of this age would need a supplementary food in addition to breast milk; this weaning food would, ideally, be based on locally available foods. In the sorghum and millet areas, a thin gruel made from these cereals and mixed with milk or a little sugar, constitutes a good introductory weaning food. [Editor's note: c.f. Greiner's distinction between weaning and complementary foods.] Between 6 and 12 months, a well-balanced sorghum or millet basic mix (or preferably a multimix) is essential. It is mandatory that breastfeeding and the provision of weaning food should continue together for 2-3 years, until the child is ready to share the family pot. In this paper, an attempt is made to elucidate critically the advantages of sorghum and millet weaning foods and to emphasize their importance for child survival and development. Experiences are drawn mainly from the Iringa Nutrition Programme in Tanzania.

Experiences from the Iringa Nutrition Programme

Tanzania's Iringa Nutrition Programme, organized by the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), and their Joint Nutrition Support Programme (JNSP), seeks, under its mandate, to reduce infant mortality and morbidity through an integrated approach toward improving the nutritional status of children under 5 years. The program started in December 1983, with 168 villages from seven Divisions; it now covers 50,000 children under 5 years, and is expanding to cover the whole region of more than 600 villages. Weaning foods are a priority in the program, and are being promoted on a systems approach basis, with a conceptualization of problems, causes, and interventions (Table 1).

Campaigns

Nutrition campaigns have been of great assistance in mobilizing improved feeding and growth monitoring of children. The 1984 campaigns in Iringa had the following impact in 168 villages where a locally produced film was screened: all children were immunized, the use of "power flour" ("kimea") made from finger millet was demonstrated, and all the children were fed with this improved porridge. Emphasis was placed on the use of green leafy vegetables and oilseeds, such as pumpkin seeds, groundnuts, and sunflower seeds; a village-based system for monitoring child growth was established. This experience was recently used to promote an expansion of the program into another 425 villages in Iringa.

Table 1. Logistics of selection of program interventions related to food security.

Problem	Possible causes	Program intervention
Inadequate food in households (very severe in few months before harvest)	Lack of household planning Choice of wrong crops Failure of rains Poor crop management Storage losses	Training of trainers on household food production planning Promotion of drought-resistant crops, such as sorghum, sunflower, cowpea, and especially cassava Improved storage
Inadequate nutrient intake	Poor economic resources Nutritionally poor diet Shortage of fuelwood Shortage of fruits and vegetables Scarcity of small animals	Promotion of income-generating activities Nutrition education (especially mothers) through village health workers Training and inputs for village afforestation and home gardening Training and inputs for keeping of small animals
Bulky weaning foods and inadequate feeding	Lack of awareness of children's needs and of nutrient value of prepared foods Inadequate feeding frequency Scarcity of energy-dense items, such as groundnuts and cooking oil Bulky starch foods Too much workload	Provision of weaning recipes based on local foods Promotion of breast-feeding Education of mothers; provision of "community contributed meal" Promotion of production and processing of sunflower Campaign on use of "kimea" (power flour) Training in appropriate technology (use of hand mills, etc.)

Source: Seenappa (1987c).

Sorghum and Millet Diets and Nutrition

Sorghum is produced on 4.8 million ha of land in Africa. In these areas, nearly 70% of dietary protein and energy intake is, therefore, supplied locally by sorghum and millet products, and millions of children are given weaning foods made with these grains. Observations on the quality of sorghum and millets have so far been based on rat-feeding trials in the laboratory; surveys or trials in the field have been limited. In this paper, an attempt is made to compare the performance of children in sorghum-dominated areas with that of children in maize-dominated areas.

A village-based monitoring system is functioning very successfully in Iringa. About 50,000 children under 5 years are weighed every 3 months. The village health workers take advantage of these weighing sessions to talk with the mothers, stressing the benefits of foods that are locally produced. The use of "kimea" is always recommended. The available data on children's weight enabled us to compare the nutritional status of children in the sorghum-dominant area (Pawaga) with that of children in the maize-dominant areas (Table 2, Fig. 1). The reduction in levels of moderate malnutrition, as well as of severe malnutrition, was found to be comparable in the two areas. The mobilization of mothers and their informal education on improved child feeding may well be responsible for this reduction in malnutrition.

Results of Luganga Trial

Luganga is one of the "Ujamaa" villages in Iringa Region, Tanzania. The staple crop in this village is sorghum. Because of constraints in processing the 'Serena' sorghum, villagers often trade sorghum for maize.

Observations from Other Countries

Studies in other countries have also shown the advantages of using improved sorghum/millet weaning foods to enhance the nutritional status of young children. Pushpamma et al. (1979) and Pushpamma and Devi (1979) have demonstrated the usefulness of dehulled sorghum and local grain legumes for increasing the nutritional status of preschool children in villages around Hyderabad, India.

In Uganda, cereal-based weaning foods (such as sorghum, millet, banana, or maize) were supplemented with "jiko" (a paste made from groundnuts and sesame) and this cereal was then fed to 68 children with severe PEM. A comparison between children on a milk-based diet and those on the cereal-"jiko" diet showed that the latter group recovered at least 1 week earlier, and that their mortality rate was 1.3%, compared with a rate of 11.5% for children on milk diets (Kakitahi 1985).

Table 2. Comparison of children (under 5 years of age) with moderate malnutrition in sorghum-dominant areas with those in maize-dominant areas, Iringa Nutrition Programme, Tanzania.

		% moderate malnutrition during 2nd quarter of:			
Division	**Main crop**	**1984**	**1985**	**1986**	**1987**
Pawaga	Sorghum	50.26	36.42	40.93	37.57
Ifwagi	Maize	57.42	49.57	43.14	43.78
Wanging'ombe	Maize	52.53	39.13	35.79	34.73

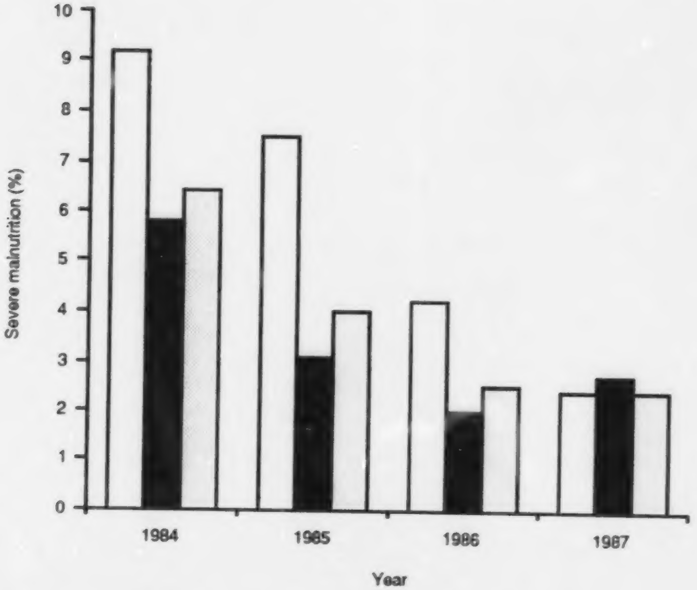

Fig. 1. Comparison of percentage of children (under 5 years of age) with severe malnutrition in a sorghum-dominant area (Pawaga, □) with those in a maize-dominant area (Wanging'ombe, ■) for the 2nd quarter of the years covered (□, region).

Studies by Brandtzaeg et al. (1981) in several South Indian villages showed that combinations of sorghum and green gram, or of finger millet and green gram, produced nutritive weaning foods with good acceptability, and that these foods had the effect of accelerating weight gain in the children.

In Ethiopia, Svanberg and co-workers (personal communication) executed a 20-day trial, wherein 20 preschool children were fed porridge made with "power flour" or germinated sorghum. This bulk-reduced porridge contained 25% more flour and was, therefore, 25% more nutrient dense than untreated porridge. Despite the short duration of this trial, the bulk-reduced porridge could be seen to have a positive effect on the nutritional status of the children.

Thus, reports from many countries show that sorghum- and millet-based weaning foods influence the nutritional status of young children; this is especially true when the children are fed a weaning mix that includes a legume. These reports also show that the use of malted millet or sorghum helps to reduce dietary bulk, thus increasing the nutrient density of the weaning food.

As observed by Eggum et al. (1982), a diet that consists only of sorghum, and that therefore has a low lysine content, does not allow adequate utilization of protein and energy. If, however, the sorghum is combined with other foods that are rich in lysine, the protein and energy are used more effectively. This observation is supported by other feeding trials with preschool children (Pushpamma and Devi 1979; Pushpamma et al. 1979).

The studies cited above, although few, do indicate that when feeding is sufficiently frequent, and dietary intake adequate, then sorghum- and millet-based weaning foods can have a positive effect on weight gain in children. A successful promotion of these weaning recipes would, however, require the sort of package used in Iringa, promoting production, processing, and utilization.

Promotion of Sorghum and Millet Weaning Foods

Field Experiences

There is currently a major emphasis in the developing countries on formulation and promotion of appropriate recipes based on locally available foods. Community participation is essential in nutrition education and in monitoring child growth (Hendratta and Johnston 1978). Because sorghum- and millet-based weaning foods are regaining their position in the food systems of sub-Saharan Africa, there is now a concentration of attention on these foods.

In Tanzania, the promotion of proper weaning foods has a high priority: the Tanzania Food and Nutrition Centre, for example, is producing a weaning food manual specific to every region. In the Iringa Nutrition Programme (WHO/UNICEF/JNSP), the promotion is based on a conceptual analysis of household food security, as presented in Table 1 (Seenappa 1987c). Promotion of sorghum and millets constitutes a package that includes

- promotion of production of sorghum and cowpeas (Table 3);
- promotion of minidehullers for sorghum and cowpea;
- promotion of appropriate recipes; and
- promotion of "kimea" or "power flour," with nutrition education on dietary bulk reduction.

Traditional Home Processing

Traditionally, grain pounding (dehulling) is a woman's job in the household. More commonly, wet-grinding is practiced (with inclusion of about 2% moisture). In remote villages in sorghum and millet areas, a flat granite stone and a small rubbing stone or roller-type stone pestle are used. More commonly, however, a wooden mortar and pestle ("kinu") is used. In 1 h, a woman usually pounds and processes 2-2.5 kg of sorghum. Because many flour particles are lost through crude dehulling and hand winnowing, the extraction rate is around 60%. Flour thus obtained is very moist, with a water content of 30-40%; it can, therefore, be stored for only 1-2 weeks. Furthermore, sorghum flour has a very high fat content - higher even than that of maize; this high fat content can also reduce the storage capability of the flour.

Sorghum processing constitutes a strenuous workload for women in the semi-arid tropics. In sorghum-growing areas in Tanzania, women spend several hours every day, beginning in the early morning, pounding and processing sorghum (Seenappa et al. 1984). The time

Table 3. Distribution of drought-resistant crops among villages in Pawaga Division, Iringa Rural District, 1986-1987.

		Main crop		Communal pilot		Demonstration	
Village	Population	Crop	Area (ha)	Crop	Area (ha)	Crop	Area (ha)
Kimande	3000	Sorghum	246	Sorghum Cowpea	31 6	Cassava	1.2
Itunundu	1385	Sorghum	185	Sorghum Cowpea	23 2	Cassava	1.2
Mooliboli	1167	Sorghum	194	Sorghum Cowpea	24 4	Cassava	0.8
Kisanga	843	Sorghum	204	Sorghum Cowpea	24 2	Cassava	0.8
Isele	1058	Sorghum	97	Sorghum Cowpea Groundnut	16 5 4	Cassava	0.8
Luganga	1060	Sorghum Cowpea Pigeon pea	104 10 3	Sorghum	16	Cassava	0.8
Magozi	620	Sorghum	84	Sorghum Cowpea Pigeon pea	16 10 2	Cassava	0.8
Ilolo	599	Sorghum	80	Sorghum Cowpea Pigeon pea	16 10 2	Cassava	0.8
Mkombilenga	541	Sorghum	67	Sorghum Cowpea Pigeon pea	16 6 3	Cassava	0.8

Note: During November-December 1986, the Iringa Nutrition Programme supported the launching of a campaign to promote cassava and other drought-resistant crops; this was followed by the supplying of cassava cuttings, of 9000 kg of sorghum, and of pigeon pea and cowpea seeds.

Source: Seenappa (1987a, b).

spent on this task amounted to nearly 2 full days in a week. In general, the red varieties of sorghum have always required more time. Despite problems with dehulling and processing, sorghum is still a staple for an estimated six million people in Tanzania (Tanzania Food and Nutrition Centre, Dar es Salaam). The situation is similar in most of the sub-Saharan countries of Africa. An affordable, alternative technology would greatly reduce the women's workload and would increase the use of sorghum and millets; such a technology would also allow for the production of better food, especially for children.

A study in a sorghum-growing Tanzanian village (Tobisson 1980) found that women spent about 8.7 h/day on nonagricultural activities, including collecting water, fetching firewood, milling, grinding, and preparing food. In his explanation of the role of women in the postharvest conversion of food, Brandtzaeg (1982) observed that in the household, 83% of food processing was done by women, 15% by girls, and none by men.

The International Development Research Centre (IDRC) has maintained its support of appropriate milling systems, especially sorghum dehullers in sub-Saharan Africa, and has created a network of mutual help among these countries. This is, however, only a small beginning: effort is required from every policymaker, researcher, and administrator to lighten women's workload by making the technology accessible and affordable.

Mechanical Milling Systems

Dehulling, winnowing, and pulverization are three important steps in grain milling; when the appropriate power is added, either from diesel engines or from electric motors, a complete milling system is formed. To be successfully disseminated in the rural areas, however, these milling systems must be simple, viable, and affordable.

Since 1976, IDRC has been supporting research into improving and simplifying milling systems for sorghum in sub-Saharan Africa. Support given to the Rural Industries Innovation Centre (RIIC), Botswana, resulted in the modification and improvement of the prototype dehuller provided by the Prairie Regional Laboratory (PRL) of the National Research Council of Canada. The PRL type had already been tested in Botswana, in Maiduguri, Nigeria, and in Senegal. The modified PRL dehuller came to be known as the RIIC/PRL type. A smaller version known as a minidehuller was later developed by the PRL as a laboratory mill, and has now been introduced in many countries (Schmidt 1983).

The PRL dehuller has 13 carborundum stones of 30 cm diameter, evenly spaced on a 92-cm shaft (Fig. 2). The bran is aspirated by a fan to a cyclone. This dehuller is suitable for a fairly large-scale operation with continuous flow and is used for sorghum, millet, cowpeas, and maize.

The RIIC/PRL dehullers are similar to the PRL type, but smaller. They can be used as a batch- or continuous-flow type. The carborundum stones are 25 cm in diameter. Although they can be used as a service mill, each needs a daily throughput of 1.5 t to be economically viable.

The minidehuller (PRL) is a smaller, simplified version of the batch-type dehuller, fabricated first by PRL (now the Plant Biotechnology Institute) and intended to dehull small batch samples of 2-8 kg of sorghum and many grain legumes (Reichert et al. 1984). This machine (Fig. 3) is low in cost, simple to operate, and highly suitable as a service mill for small villages or communities. It takes less than 5 min to dehull one 5-7 kg batch of sorghum. This machine operates either with an electric motor or with a 5-hp diesel engine. Because there is no cyclone to aspirate the bran, it has to be separated by hand winnowing.

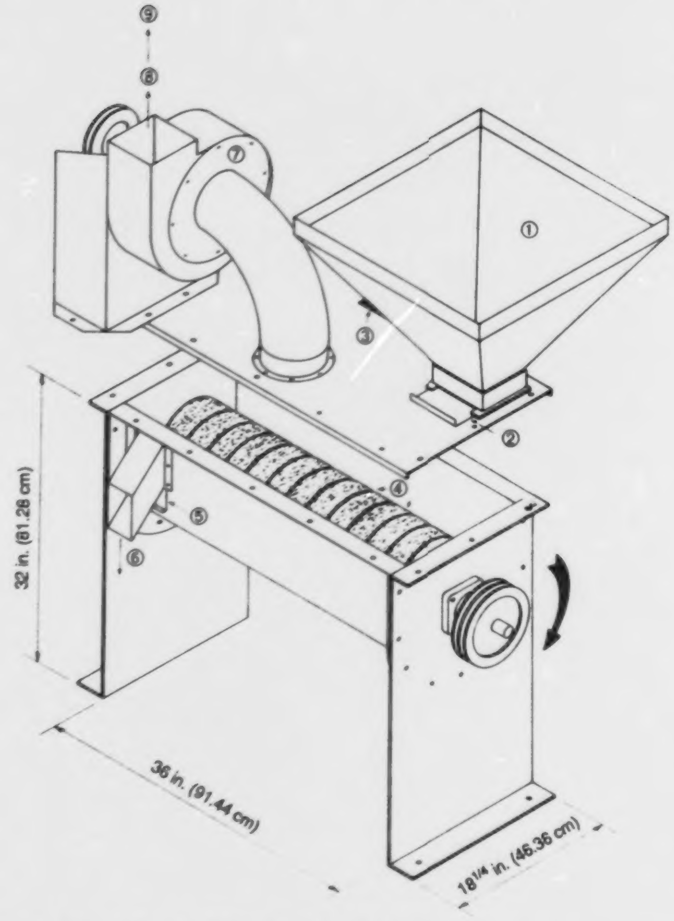

Fig. 2. The PRL dehuller is identical to the PRL/RIIC dehuller, except that the latter has a hinged door on the bottom to allow the dehulled cereal to drop into a collecting basin. 1, grain hopper; 2, feed gate; 3, air inlet; 4, carborundum stones; 5, adjustable gate; 6, overflow outlet (dehulled grain); 7, fan; 8, bran; 9, to cyclone.

The minidehuller has been successfully tried in Egypt, Guatemala, India, the Philippines, and Thailand, as well as many countries in Africa. The RIIC/PRL-type dehullers were initially introduced into Tanzania by the Small-scale Industries Development Organization (SIDO) with the support of IDRC; the minidehuller tried in Morogoro (Sokoine University) and in Iringa has proved to be more of a service mill, targeted mainly at subsistence farmers.

After the sorghum has been dehulled, it is ground into flour – a process known as "pulverization." Hammer mills are mainly used for

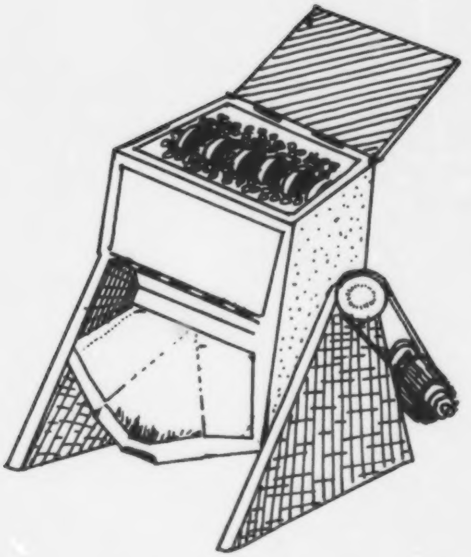

Fig. 3. PRL minidehuller.

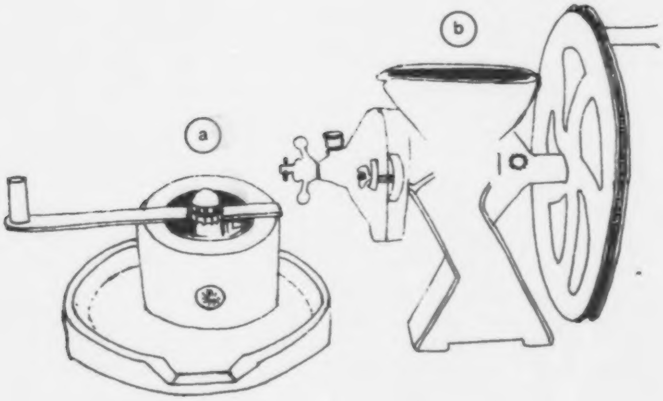

Fig. 4. (a) Samap and (b) Diamant hand mills.

this purpose in most countries in sub-Saharan Africa; they are produced locally and are therefore readily available to village cooperatives or even to private individuals.

Local availability of dehullers is, however, still a problem. Botswana and Tanzania are producing these on a small scale. The only limiting factor is the importation cost of carborundum stones or resinoid discs.

In place of hammer mills, hand-grinding mills are being promoted as affordable machines in several countries. In Tanzania, SIDO is producing hand mills based on the "Atlas" design. These cost about 5000-6000 TZS (in 1988, 69 Tanzanian shillings [TZS] = 1 United States dollar [USD]). As the production is on a very small scale, the other common types being imported are the "Samap" and the "Diamant" types (Fig. 4), the former costing USD 60 and the latter, USD 110 (prices in July 1986).

Milling Properties

Different from millet in structure and composition, sorghum is the more difficult of the two to mill and process. Red, high-tannin varieties of sorghum pose more problems than do the yellow and white varieties: because the darker varieties need longer dehulling, their extraction rates are very low (Table 4). The milling properties of sorghum also vary according to the type of milling practiced - wet or dry. Furthermore, the nature of the endosperm in the grain affects the way in which this grain is broken: of the soft, medium, and hard types of endosperm, the soft type breaks too easily, making its grain very difficult to dehull. In Tanzania, the varieties available include 'Serena,' with soft endosperm; 'Lulu,' with medium endosperm; and Bihawana local and Gairo local, with hard endosperms. These all exhibit concomitant variations in milling properties. Mechanical dehulling is easier for the hard type of grains: with these, it is possible to attain a uniform pearling or polishing, and to secure good extraction rates (Eggum et al. 1982; Bangu 1986).

As with other cereal grains, the pearling or polishing of the sorghum grain results in the loss of some nutrients. To show which of these are vulnerable, Table 5 illustrates the distribution of nutrients in the sorghum grain (Fig. 5).

Table 4. Extraction rates of some sorghum varieties after dehulling.

Sorghum variety	% content				Extraction rate (%)
	Whole grain		Dehulled grain		
	Ash	Fat	Ash	Fat	
Durra yellow	1.70	3.22	1.08	1.81	80
Durra red	1.58	3.60	1.06	2.38	74
USA red	1.48	3.25	3.25	1.27	65

Table 5. Distribution (%) of nutrients in sorghum grain.

	Scutellum	Embryo	Endosperm	Aleurone
Thiamine	62	2	3	32
Riboflavin	14	12	32	37
Niacin	1	1	12	82
Protein	4.5	3.5	72	16

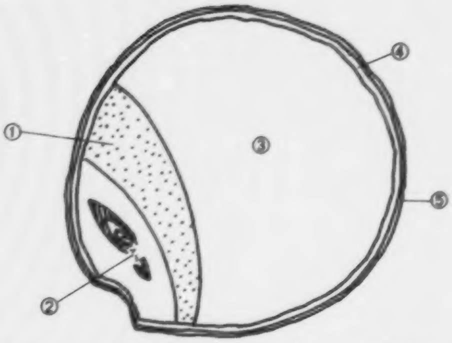

Fig.5. Anatomy of a sorghum grain. 1, scutellum; 2, embryo; 3, endosperm; 4, aleurone layer; 5, pericarp and testa.

A number of weaning recipes (Table 6), suitable for household preparation and based on sorghum and millets, are being promoted through appropriate nutrition education in a number of African countries.

Table 6. Sorghum and millet weaning recipes.

Ingredients	**Quantities**	**Comments**
		Tanzania
Sorghum	75 g	Cassava leaves are pounded well before adding Final gruel solids 7.5%, viscosity reduced by addition of 1% w/w "power flour" (Mosha 1984)
Kidney beans	25 g	
Cassava leaves	10 g	
Sorghum	75 g	Cowpeas used as slightly roasted flour, giving the aroma of groundnut. "Power flour" (5 g) added when "uji" is ready (JNSP-Iringa) (TFNC)
Cowpeas	25 g	
Greens	10 g	
Cooking oil	5 g	
Sorghum flour	140 g	Proposed for 1-2 year olds. Energy, 1095 kcal; protein, 50.6 g; calcium, 818 mg; iron, 13.9 mg; vitamin A, 1220 IU; vitamin C, 40 mg (Van Rossum 1984)
Cowpeas	100 g	
Dry fish ("dagaa")	20 g	
Vegetable oil	20 g	
Dark-green leafy vegetable		
Sorghum flour	90 g	Proposed for 6-12 month olds. Energy, 617 kcal; protein, 25 g; iron, 6.5 mg; vitamin A, 900 IU; vitamin C, 30 mg (Van Rossum 1984)
Groundnut	30 g	
Dry fish ("dagaa")	10 g	
Sugar	20 g	
Dark-green leafy vegetable	30 g	
Water	500 mL	

(continued)

Table 6. Concluded.

Ingredients	Quantities	Comments
		Lesotho
Sorghum flour[a]	30 g	
Beans/peas	30 g	
Egg	1	
Pumpkin leaves	30 g	
Sorghum flour[a]	30 g	
Egg	1	
Sugar	10 g	
Cooking oil	5 g	
Sorghum flour[a]	30 g	
Milk	250 mL	
Sugar	10 g	
Sorghum flour[a]	30 g	
Beans/peas	30 g	
Cooking oil	5 g	
Salt	to taste	
Sorghum flour[a]	30 g	
Tomato	1 medium	
Meat/fish/chicken	30 g	
Cooking oil	5 g	
Salt	to taste	
		Ethiopia
Multimix		
Sorghum flour	50 g	Mix sorghum, pea flour, and fenugreek with water; bring to boil, stirring well; add oil and sugar; cook gently for 15 min; add a little salt to taste. Energy, 295 kcal; approximate volume, 150-200 mL
Field pea flour	10 g	
Fenugreek (soaked overnight)	5 g	
Oil	5 g	
Sugar	5 g	
		Nigeria
Sorghum flour	50 g	Mix flour smoothly with a little water; add more water and bring to the boil; add evaporated milk and sugar. Energy, 205 kcal; approximate volume, 150 mL
Sugar	5 g	
Milk, evaporated	5 g	
Sorghum flour	40 g	Mix the bean flour to a smooth paste with a little water; add some more water, bring to the boil, and cook gently with the chopped onion; when nearly cooked, add the sorghum flour and stir well; cook a further 15-20 min, add the oil. Energy, 270 kcal; approximate volume, 200-250 mL
Bean flour	20 g	
Red palm oil	5 g	
Onion	5 g	

Sources: Cameron and Hofvander (1983) and Lehloba (1985).

[a] Millet could be used in place of sorghum.

There have been attempts, most of them successful, to produce sorghum/millet-based weaning foods on a semicommercial scale, often using the extrusion and malting technology. These foods have been promoted as "high energy" and "high protein"; some have become popular in the supplementary feeding programs and at nutrition-rehabilitation centres and in hospitals. For household utilization, however, some of these products will have to be made more affordable.

Conclusions

- Sorghum and millets have a vital role to play in food security in sub-Saharan Africa.
- Millions of mothers are weaning their children on sorghum and millet porridges. When prepared in the traditional manner, however, these porridges are bulky and very low in overall nutrient density, as well as in energy content.
- Several basic and multimix recipes are now available for preparing sorghum- and millet-based weaning foods; these recipes are based on locally available and acceptable ingredients.
- Affordable technologies are now available for dehulling sorghum, with a view to decreasing women's workload, and to increasing the digestibility of the foods. Hand mills have proved very useful, especially in Tanzania.
- Although lysine is a limiting factor for protein digestibility, the use of legumes in weaning food preparations would help to alleviate this problem.
- Of growing popularity in Tanzania, "kimea" or "power flour," prepared from malted finger millet or sorghum, helps to reduce dietary bulk and to increase the energy density of the food.
- Nutrition campaigns, such as those undertaken in Iringa, Kagera, Shinyanga, and other regions in Tanzania, have provided opportunities for effective nutrition education at the village level; this is especially true for education on improved child feeding and on the use of "power flour."
- The Iringa Nutrition Programme has been studying the levels of moderate and severe protein energy malnutrition in children under 5 years. The program operates in areas dominated by sorghum as well as in those dominated by maize; results from the two areas have been found to be comparable, with regard to lowering levels of malnutrition.
- The Luganga study in Tanzania showed that "power flour" was well accepted by the mothers: in fact, they already knew how to make it. In this study, the effect on weight gain was demonstrated in about 40 children over a period of 3 months.
- There have been attempts in Africa and in India to use malted millets on a semicommercial scale for the preparation of weaning foods; in several countries, this has been successful. The resultant products seem, however, to be used mostly in rehabilitation

centres and in hospitals. A more widespread use of sorghum and millets for weaning-food preparation would depend very much on the popularization of household technologies.

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WEANING FOOD PROVISION IN REFUGEE SITUATIONS

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Abstract *Because of conditions in refugee situations (food shortages, crowding, poor water and sanitation, and severe social disruption) children of weaning age in these situations are at high risk of malnutrition and of associated morbidity and mortality. Access to appropriate amounts and types of weaning foods is critical to the survival of these children. In refugee situations, the availability of these foods is dependent on the following factors: distribution of general food rations (GFRs) of adequate quantity and quality; availability of facilities for preparation (tools for grinding, water, and utensils); and education of refugees in the preparation of unfamiliar foods. In this report, we review published recommendations and practices concerning the provision, through GFRs and through supplementary feeding programs (SFPs), of weaning foods to refugees. We also present an algorithm to evaluate this provision of weaning foods, and we review factors to be considered in the composition of the weaning diet. Because SFPs have limited coverage (caused by selective eligibility and by low registration and attendance), they are not viable mechanisms for providing weaning foods to children in most refugee situations. It must also be recognized that these SFPs provide only a portion of the children's energy requirements. Any evaluation of total ration provision must, therefore, include a consideration of the special needs of weaning age children.*

Introduction

Because of conditions in refugee or famine situations - food shortages, crowding, inadequate supplies of water, poor sanitation, and severe social disruption - infants and young children in these situations are at high risk of malnutrition and of associated morbidity and mortality. As long as satisfactory growth can be maintained, exclusive breastfeeding is the preferred mode of feeding and should be strongly encouraged in early infancy. Between 4 and 6 months of age, however, infants require additional food to support their increasing nutritional needs. During this weaning period (i.e., the transition period from full breastfeeding to consumption of the family diet), the use of appropriate weaning foods is critical to the survival of refugee children. In this report, "weaning foods" are defined as foods that are appropriate to the weaning period and that can be easily incorporated into child feeding.

The provision of weaning foods constitutes a serious problem in refugee situations. In general, weaning-age children in camps receive food through two major mechanisms: the general food ration (GFR) and the supplementary feeding program (SFP). SFPs are usually directed toward malnourished children, rather than to the entire population of weaning-age children; children who do not attend SFPs must, therefore, rely on the GFR as the source for their weaning foods. GFRs are, of necessity, provided from easily available commodities that may not be familiar to refugees, and that may be inadequate in quality and quantity; the absence of familiar weaning foods can lead to a disruption of traditional weaning practices.

We must also consider those resources needed to store, prepare, and use weaning foods: these resources, including grinding equipment, clean water, cooking fuel, and utensils, may be unavailable in many refugee situations.

In this report, we review the recent experience culled from several refugee settings. We raise issues related to providing weaning foods to these populations; review published recommendations for refugee GFRs and SFPs; compare SFPs with GFRs as mechanisms for providing weaning foods in refugee settings; and examine weaning diets that can be prepared from foods available to refugees in actual relief settings. More attention to all of these issues may help to reduce the high malnutrition rates often seen in weaning-age refugee children.

Published Recommendations

We examined the recommendations of major United Nations (UN) and other organizations for the provision of general rations, weaning foods, and supplementary feeding programs in emergency situations (de Ville de Goyet et al. 1978; UNHCR 1982; Simmonds et al. 1983; OXFAM 1984; UNICEF 1986; Brown and Berry 1987). Recommendations for total energy requirements in long-term relief operations generally range from 1800 to at least 2000 kcal/person per day; in emergency (early) phases of these operations, from 1500 to 1800 kcal for short-term survival. All organizations recommend that this energy be provided through a combination of sources: a staple food (cereal), a protein food (legume, oilseed, dried skim milk, etc.), and an energy-dense food (oil).

Specific recommendations are made for preparing weaning foods from available provisions (UNICEF 1986; Brown and Berry 1987): it is recommended that energy-dense, protein-rich foods be distributed, that the use of these foods be demonstrated, and that the equipment needed to prepare weaning foods be provided. It is suggested that, under special circumstances - where there is a shortage of fuel or of other necessities, where the camp is in the early phases of relief, or where distributed food items are unfamiliar - communal preparation of weaning foods would be appropriate.

The purpose of SFPs is to provide nutritional support to vulnerable groups. SFPs are intended as a supplement to, and not a replacement for, the GFR. The foods provided should be high in energy and in protein but low in bulk. The total recommended energy for supplementary feeding programs of children under 5 years of age ranges from 350 to 500 kcal. Both the Oxford Committee for Famine Relief (OXFAM) and the United Nations Children's Fund (UNICEF) recommend an increase in caloric intake (500-1000) in situations where the GFR is inadequate.

Unlike GFRs, which are aimed at the entire population, SFPs are most often targeted at specific groups: undernourished children, pregnant and lactating women, and medical referrals. Where resources are limited, poor nutritional status is considered a requirement for admission into SFPs for children less than 5 years of age (UNHCR 1982; Simmonds et al. 1983; OXFAM 1984; UNICEF 1986; Brown and Berry 1987). The World Health Organization (WHO) did not specify poor nutritional status as a criterion for program eligibility of children less than 5 years of age (de Ville de Goyet et al. 1978).

Monitoring of program participation is essential. Because SFPs usually require that the child attend a feeding centre, eligible children may not always participate because of the time needed on the part of their caretakers. Furthermore, parents may take to the centre those of their children who need it least: often those who are in the worst condition are left at home, the parents having given up hope for the child's survival (OXFAM 1984). Most sources recommend active case finding (usually through door-to-door surveys) and, once these cases are identified, active follow-up.

Supplementary Feeding Versus General Ration Distribution

General food ration programs and supplementary feeding programs are compared in Table 1. SFPs fall into two general types: take-home and on-site. General food ration programs have several advantages over SFPs: the distribution of weaning foods through GFRs costs less (at least, in theory), is simpler, and involves fewer additional resources, either from the program or from the family; by incorporating the distribution of weaning food into a general ration program in which the entire population participates, a higher proportion of families with weaning-age children can benefit. With this system, however, there is less opportunity either for monitoring the nutritional status of the participants or for linking up with maternal child health programs. Furthermore, because the food is distributed to the families rather than directly to the children, other family members are likely to eat the food that has been designated for the weaning-age child.

Refugee feeding programs should ensure the availability, either through GFRs, through SFPs, or through a combination of the two, of adequate weaning foods for children. Figure 1 shows an algorithm that assesses the adequacy of children's access to appropriate weaning foods in refugee situations. Weaning foods provided through the GFR are deemed adequate if they meet the criteria of sufficient quantity and quality, and if facilities and equipment are available to prepare weaning foods from the distributed commodities. If the GFR distribution system does not provide adequate weaning foods, then the adequacy of foods distributed through SFPs must be evaluated. To be adequate

Table 1. Distribution of weaning foods to refugee children by general food ration and by supplementary feeding programs.

	General food rations	Supplementary feeding programs[a]
Family coverage	++	+/- (-)
Child focusing	+/-	+ (++)
Extra resource need		
Program	++	- (--)
Mother/father	++	- (--)
Support for appropriate cultural feeding practices	++	++ (+)
Opportunity for monitoring	-/+	+ (++)
Opportunity for linkage with maternal child health centres	-/+	++ (++)

Note: ++, very advantageous; +, advantageous; -, disadvantageous, --, very disadvantageous,

[a] On-site programs are indicated in parentheses.

on a population basis, SFPs must fulfill the following criteria: they must be available to all children of weaning age; they must have high program participation; and they must provide rations of adequate quantity and quality. If an SFP fails on any of these counts, it cannot be considered a satisfactory source of weaning foods for children in the affected population.

Factors Influencing the Production of a Weaning Diet from Available Foods

Jelliffe (1971) has listed six factors to be considered in producing a weaning diet: nutritional requirements, food availability, ease of preparation, cultural acceptability, physiologic acceptability, and bacterial content. We review these factors as they pertain to GFR distribution in several refugee and disaster food programs.

Nutritional Requirements and Availability

GFRs for several recent refugee relief operations are shown in Table 2. The operations reviewed were chosen because documentation was available and because of the wide spectrum of program types. The table presents each of the GFRs in a particular year of their operation. Obviously, the conditions both of the camps and of the food baskets would have changed over time; these GFRs can, however, serve as examples for discussion.

Because of the logistical and political problems of food distribution, the actual amount of food received may be much less than expected. With the exception of Honduras and Thailand, the total

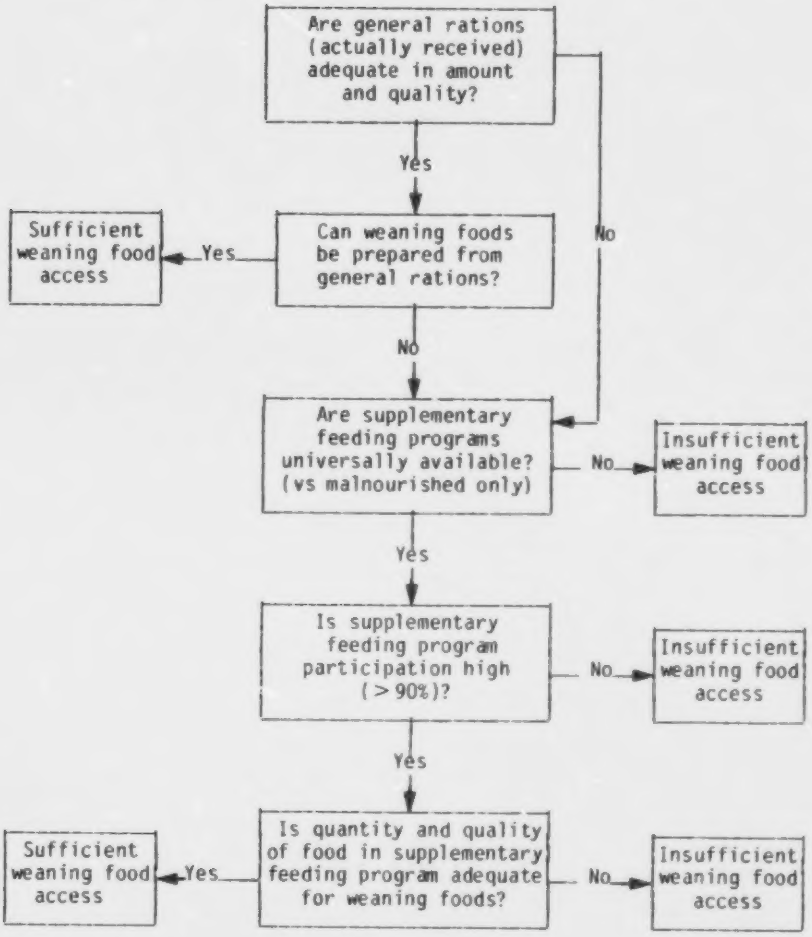
Are general rations (actually received) adequate in amount and quality?
Yes
No
Can weaning foods be prepared from general rations?
Yes
Sufficient weaning food access
No
Are supplementary feeding programs universally available? (vs malnourished only)
No
Insufficient weaning food access
Yes
Is supplementary feeding program participation high (> 90%)?
No
Insufficient weaning food access
Yes
Is quantity and quality of food in supplementary feeding program adequate for weaning foods?
Yes
Sufficient weaning food access
No
Insufficient weaning food access

Fig. 1. Algorithm to assess adequacy of access to appropriate weaning foods in refugee populations.

energy allotment actually received was far below the projected energy requirement for an entire family.

Many of the food baskets examined were not balanced with respect to micronutrients (vitamins A, C, and B1, and iron). Micronutrient deficiency diseases have occurred in several relief operations, particularly among refugees, who rely entirely on donor aid over an extended period. The nutritional status of the refugee child (often not optimal even at the beginning of his or her term as a refugee) may further deteriorate after a prolonged stay in a camp. Scurvy or vitamin C deficiency occurred both in Somalia and in Sudan (Magan et

Table 2. General food rations distributed to refugees by country.

Country	Staple (g)	Protein source (g)	Oil (g)	Other (g)	Total calories	Comments
Bangladesh (1978)	Rice and wheat flour (465 - adult) (233 - child)				1300	
Honduras (1984)	Corn (320) Rice (85)	Beans (65) Milk (40) Protein (30)	40	Sugar (50) Salt (15) Coffee (15) Vegetables/ fruit (100)	2556	
Northwest Somalia (1980)	Rice (100-200) Flour (60-100)	Dried skim milk (60)	60		1330 (average)	Probable overestimate of actual distribution
Southern Somalia (1985)	Wheat (200-250) Rice (0-250) Wheat flour (100) Maize flour (0-30)	CSM (0-30) Dried skim milk (30)	30	Dates (0-20) Salt (20)	1523 (average)	
Eastern Sudan (1985)	Wheat flour (400)	Lentils (60)	30		1744 (expected)	Actual food distribution; 400 g wheat flour
Thailand (1980)	Rice (450)	Fish (30) Beans (50) Meat (15)	30	Fish sauce (5) Vegetables (70)	2140	

Sources: Aall 1979; CDC 1980; Eie 1980; Enos et al. 1984; Mackie 1985; UNHCR 1986.

al. 1983; COR Health Unit 1985). After the government in Somalia had closed markets that were near the camps, more than 2000 cases of scurvy developed in those camps; the disease appeared 3 years after the refugees had first arrived (Magan et al. 1983). Vitamin A deficiency appeared among refugees in Sudan and Thailand (CDC 1983; COR Health Unit 1985). To prevent these deficiencies, specific vitamin supplementation in the diet may be needed in some situations. Where dried skim milk (DSM) is distributed, it should always be fortified with vitamin A and clearly labeled as such.

Ease of Preparation and Cultural Acceptability

To make use of these weaning foods, the mothers must have the facilities with which to prepare foods suitable to a very young child. The mothers need either a ground staple or access to grinding facilities, clean water, fuel, and, ideally, a separate bowl for the child. Community grinding equipment specifically earmarked for weaning-food preparation may be useful; this equipment could be attached to the maternal child health centres. Another approach could lie in distributing appropriate weaning premixes (e.g., grain, legumes, and oilseeds) as dry take-home rations. Appropriate premixes could be prepared through extrusion technology. The extrusion process produces a precooked product that is more easily digested and that has an extended storage life (Hornstein 1986). The form in which the food is distributed may be important for other reasons: in the Sudan, for example, wheat flour intended for baking was distributed; because of its high gluten content, however, it was inedible as a porridge (Brown and Berry 1987).

Where possible, foods given to recipients should be familiar and culturally acceptable. It is often the case, however, that surpluses dictate the choice of food to be distributed. To make unfamiliar foods palatable or, in the case of DSM, to prevent adverse consequences from misuse, refugee populations need instructions for preparing these foods. Dried skim milk is a commonly available item that is usually not part of any indigenous diet. Because it clearly has the potential for misuse as a breast milk substitute, DSM should be distributed only as part of a dry mix and not as a liquid. Instructions for its appropriate preparation (e.g., mixing with gruels) must be provided. Dried beans are another example of a food for which cooking instructions must be provided. In Somalia in 1982, beans were distributed without explanation as to their preparation. The refugees tried, unsuccessfully, to cook the beans without first soaking them. After cooking classes had been instituted, the refugees successfully incorporated the beans into their diet (M. Toole, personal communication).

Acceptability for Consumption and Bacterial Contamination

Food deterioration (e.g., rancid oil) may result in a product unfit for human consumption. Donated foods should be clearly labeled, with an expiry date on bags or containers.

Foods must be physiologically acceptable to the child: they are unacceptable if adequate quantities cannot be ingested (e.g., if the food is not calorically dense or if the child is fed infrequently) or if, because of inadequate cooking or grinding, the foods are indigestible.

Prevention of food contamination requires that cooking fuel and clean water be available.

Conclusions

The needs of the weaning-age refugee child are answered through a combination of the GFR and the SFP. In most circumstances, the GFR must serve as the primary system for providing weaning foods. SFPs are designed to supplement the GFR, not to replace it. These programs do not provide all the energy required by the children; furthermore, because of selective eligibility, or because of poor attendance, many refugee children do not receive supplementary food. Because of the comparatively high cost of SFPs, most experts recommend targeting SFPs at the malnourished children. Compared with recommended GFRs, GFRs are, in reality, often deficient in energy and in other important elements. These deficiencies exacerbate existing difficulties in the provision of adequate weaning foods.

With the exception of the most recent studies, few guidelines exist to encourage the availability and utilization of appropriate weaning foods. The factors to be considered in preparing appropriate weaning foods have been relatively well delineated: nutritional requirements, availability of food, ease of preparation, cultural acceptability, and acceptability for consumption. In most of the situations reviewed, compromises have been made with regard to the incorporation of these factors into refugee feeding programs.

Recommendations

- Planning for weaning-food provision should be a routine part of emergency food program assessment. SFPs should not be relied on to provide weaning foods to children in refugee situations. The GFR must serve as the primary source for this weaning food: to evaluate the adequacy of weaning food provision, the GFR must, therefore, be assessed with consideration for the special needs of the weaning-age child. There must also be appropriate utensils and grinding tools, as well as fuel and clean water, for preparing weaning foods.

- Because the food distributed in many programs may be unfamiliar to the recipients, traditional weaning practices must be modified through demonstration and teaching.

- In addition to the GFR, distribution of appropriate weaning premixes (e.g., products of extrusion technology) should be introduced as dry take-home rations for weaningage children; this distribution could take place through the maternal child health centres. Such centres could, through cooking demonstrations, also assist in nutrition education.

- The lead agency for feeding programs should be responsible for assuring the availability of appropriate weaning foods that are of adequate quantity and quality.

- Research is needed to develop technologies appropriate to refugee situations, and to evaluate the effects on nutritional status and child mortality of failures in providing adequate weaning foods.

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DISCUSSION SUMMARY

Promotion of Breastfeeding and Improved Infant and Child Feeding Practices

The paper by Janet Bradley, Sandy Baldwin, and Helen Armstrong generated discussion on a number of points. One such point was the need to examine not only breastfeeding initiation rates but also durations of breastfeeding. It was suggested that different patterns of breastfeeding - exclusive, substantial, and token - should be examined.

H. Armstrong emphasized the importance of a clear definition for the term "weaning": this term is sometimes used to indicate a provision of foods supplementary to breast milk; it is also used to indicate a termination of breastfeeding. Mention was made of a possible programmatic objective that would establish recommended patterns of breastfeeding for a 10-month period. It was agreed that there was a need to recognize the contribution made by breast milk to the daily nutrient requirements of a child in its 2nd year; it was stressed that such recognition would be constructive only if accompanied by specific recommendations for the promotion of prolonged breastfeeding.

There was a prolonged discussion concerning the physiological need of infants to receive fluids supplementary to breast milk. The issue was clarified by information provided by two of the participants. Dr Andrew Tomkins described two research studies that had investigated this question and had found no need for additional fluids. In any event, the amount of additional fluids given by mothers is often a very small percentage of total fluid intake (often only 5 mL before a breastfeed).

Dr Ken Brown referred to a recently published study that had reached similar conclusions. Forty breastfed infants under 6 months of age were studied in Peru during the height of the summer. Infant feeding practices were observed from sunrise to 1600 h. Urinary excretion was monitored. In only four cases did urinary specific gravity exceed 1015; there was, moreover, no evidence of clinical dehydration or of attempts to conserve fluids. In another study (unpublished) in Peru, 153 newborns were followed longitudinally for 1 year. Among the data collected was information on feeding practices and on morbidity: with the addition of fluids to the breast milk diet, diarrhea prevalence rates doubled; moreover, it was determined that additional fluids were not required to maintain the hydration state of the breastfed infants.

Mention was made of the importance of identifying what were termed "points of resistance": such points create obstacles to the promotion of improved child-feeding practices, such as exclusive breastfeeding over the first 6 months of a child's life. It was suggested that one of these obstacles might be removed by the creation of legislation that would facilitate breastfeeding outside the home.

Also discussed was the fact that incorrect advice on nutrition is often given to mothers by health-care workers. Nutrition education is often seen to take little account of deeply embedded cultural practices, such as the early provision of supplementary foods. Dr Gopaldas stressed the immense difficulty and lack of success in altering these practices. She also emphasized the need for an examination of behavioural factors affecting the nutritional status of infants and children. Her experience, from the study of thousands of infants in India, confirmed her belief that infant feeding practices can be so ingrained as to preclude alteration, regardless of the amount of education provided.

The discussion then dealt with the need to ascertain what can be done about these deep-rooted practices. It was reported that changes seemed more easily effected in hospitals than at the community level. It was suggested, therefore, that a great deal of the health-care information that is currently provided might be unhelpful: for example, very little information is given to mothers who give birth at home.

The challenge put forward was that of creating weaning diets that are more sensible. Health-care workers often advise that water feeds be given to infants; it was suggested that this practice may have arisen in the 1950's, when such feeds were made necessary by the highly concentrated formulas then prevalent. The promotion of commercially prepared infant formulas may also have given rise to the belief that colostrum is bad for babies. More research was advocated on the storage capability of breast milk.

There was discussion on the treatment of neonatal jaundice. A current method of treatment is the feeding of nonbreast-milk fluids. It was suggested, however, that breastfeeding, rather than water feeds, will better help to clear the bilirubin; this can be explained by the fact that bilirubin is excreted in the stools and not passed in the urine.

There was general agreement that breast milk has been undervalued as a food for the 2nd year of life. It was also agreed, however, that practical problems exist with regard to the promotion of prolonged breastfeeding: aspects of life in the household encourage, for example, the sharing of adult food with the child, thus interfering with breastfeeding patterns.

Given the large numbers of African women initiating and maintaining breastfeeding for at least the first year of the child's life, there is an urgent need to improve the weight gain of pregnant women, and to meet the nutrient requirements of women who are lactating. Dr Seenappa pointed out that in Africa, the average weight gain during pregnancy is only around 9.5 kg (or less); in the United States, however, it is 14-16 kg. H. Armstrong recommended that data be collected and published with regard to nutritional requirements for lactation beyond the first 6 months; such information would be valuable to refugee feeding programs, most of which do not recognize the extra nutritional needs of lactating women.

A question was also raised as to the safety, for pregnant women, of breastfeeding. A. Lechtig stated that breastfeeding during the 1st trimester of pregnancy had no known detrimental effects, either to the fetus or to the mother. Continued breastfeeding into the 2nd trimester was, however, associated with a risk of low body weight, and with poor nutritional status. Another study was quoted to the effect that women who were well nourished during their pregnancy showed no diminution in body weight, despite the fact that they were also breastfeeding.

Sorghum and Millets in East Africa with Reference to Use as Weaning Foods

Dr Seenappa outlined several current problems in child nutrition: number of meals consumed per day; amount consumed per meal; energy content of the cooked food; nutrient content per unit of energy; and bioavailability of the food. He emphasized the need to examine the weaning plate as a whole, in terms of its chemical composition.

It was suggested that sorghum and millets be promoted as part of weaning-food mixtures. Given the fact, however, that lysine in sorghum is a limiting amino acid, the question was raised as to whether the lysine availability in a multimix is sufficient to support infant or child growth.

Weaning Food Provision in Refugee Situations

Stress was laid on the need for caution in advocating the modification of traditional weaning practices. Despite the short term benefits to be gained by a directive approach, generations of local knowledge and experience could be lost. It is vital, therefore, to examine current philosophy and practice with regard to the provision of food to refugee populations. Commercial feeding programs can increase dependency by removing from the mothers the responsibility for feeding; this in turn can result in adverse changes in local feeding customs, such as a disruption of breastfeeding patterns or a development of negative attitudes toward breast milk and toward certain weaning foods.

Although the need to prevent growth-faltering was recognized, it was emphasized that food is not merely a source of nutrients: it is also a social instrument that can promote or retard social development. For this reason, the provision of food is not the only answer to an emergency situation: another appropriate response might be the provision of land and of seeds and tools; it follows, therefore, that economic factors and political constraints must be borne in mind.

People classified as "displaced" (because of drought or civil disruption) are often placed in the same situation as those people classified as "refugees." The question was raised as to whether refugees are the more willing of the two groups to accept change. Such willingness could be enhanced by a change in attitude on the part of refugee workers: these workers should be encouraged to view their job as something more than the doling out of food; they appear to have little concern for considerations such as the cultural acceptability of food supplements, or the effect of these supplements on local food habits.

Session II

Weaning Practices and Promoting Change

TRADITIONAL WEANING PRACTICES IN ETHIOPIA

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Abstract *This paper reviews the studies of the Ethiopian Nutrition Institute on food intake of infants and young children. These studies indicate a significant prevalence of malnutrition, the first evidence of which usually appears after 6 months of age. Factors contributing to this situation are late introduction of supplementary foods, high incidence of infectious diseases, undesirable social taboos, and poor economic conditions. A low-cost, high-protein weaning food known as "faffa" was developed to minimize these nutritional problems; this food has had an appreciable nutritional impact on a certain sector of the child population. Breastfeeding is often continued for quite a long period, especially in rural areas. Most of the traditional weaning foods are prepared from a variety of cereals, but in such a way that the infant cannot easily consume and digest them. The concept of improved feeding of infants and young children is not well understood by most families in Ethiopia.*

Most staples consumed in Ethiopia contain adequate quantities of minerals, vitamins, and energy. Good child growth is, however, a result both of adequate intake of nutrients and of a low incidence of infection: inadequate food intake and infectious disease both reduce the efficiency of the body and, thus, the body's capability for proper use of nutrients from the food.

In recent years, several surveys on nutritional status have been undertaken; the most common indicator used has been "weight-for-height" (wt/ht). There are two advantages to this system: first, it does not require a knowledge of children's ages, which are often difficult to obtain; second, because the critical point is taken to be a weight below 80% of that normal for the height or length of the child, the system works quickly to indicate whether a situation is improving or deteriorating.

The first comprehensive nutrition survey in Ethiopia was conducted in 1957. The survey results showed that the overall nutritional status of the population was somewhat lower than that required for their level of activity. Evidence of protein energy malnutrition (PEM) and of inadequate intake of vitamins A and C was found in some segments of the population. Endemic goitre was prevalent in several areas. Mild rickets was present in up to 30% of preschool children.

Another extensive survey was conducted by the Ethiopian Nutrition Institute (ENI) in five areas representing more than half the population. This survey revealed findings similar to those of the 1957 survey: up to 6 months of age, weight of infants was comparable to that of their counterparts in developed countries; after 6 months, however, the weight-for-age ratio begins to decline. There are several factors responsible for this: principal among them are the late introduction of complementary foods and the high prevalence of childhood diseases. Social taboos and poor economic conditions exacerbate the situation.

A representative sample survey of 1510 children from 12 "kebelles" in Addis Ababa in 1985 found 2.3% of the children to be acutely malnourished (below 90% wt/ht) and 21% stunted in the 2nd year of life. Hofvander (1970) noted a goitre prevalence of 8.5% for Addis Ababa, 26.9 for Ijaji, and 53.1% for Backo.

National Strategies to Combat Malnutrition

To alleviate these nutritional problems, ENI was established in 1962 as a joint undertaking of the Ethiopian and Swedish governments. During its first few years, the Institute was engaged in collecting baseline data and in developing a low-cost, high-protein, wheat-based weaning food known as "faffa." The objective of producing "faffa" was to reach the low-income families in urban areas. It is now evident, however, that because of the higher purchasing power of middle-class urban families, "faffa" is being consumed mainly by the children of that stratum. (A notable exception to this was the role played by "faffa" in saving the lives of drought victims and displaced families during 1980-1985.) At the same time, other products such as "dube," "edget," "cerepham," and "shiro" have been developed. We now have a low-cost, sorghum-based "faffa," and arrangements are being finalized with the Swiss government to establish a defatted soya line to eliminate the need to import soya flour to fortify supplementary foods.

In Ethiopia - a close-knit, predominantly rural society - breastfeeding is often continued until the natural biological source is exhausted or until the onset of another pregnancy, especially in rural areas. The importance of colostrum for the immunity of the newborn is generally recognized. The prohibitive cost of food substitutes discourages bottle-feeding, especially in the rural population and among the urban poor. Despite this widespread acceptance of breastfeeding, policymakers should promote it through substantial revision of teaching and training curricula; the benefits would include greater knowledge of maternal nutrition and an affirmation of a social status for women apart from their traditional burden of having frequent and often unwanted pregnancies.

Traditional Weaning Practices

Between the ages of 6 and 18 months, the child moves through stage that is critical to his or her survival. One of the factors contributing to infant malnutrition is prolonging breastfeeding without an appropriate and timely introduction of complementary foods. Weaning is a process whereby foods that are both suitable and palatable are introduced when required for adequate nutrition. Weaning that begins too early involves the risk of infection; weaning that begins too late leaves the infant with an inadequate intake of nutrients and, thus, is harmful to his or her growth and development. Several factors must be considered with regard to supplementary foods: nutrient value, ease of preparation, hygiene, digestibility, and density. The practice of supplementation calls for attention to the frequency and consistency of feeding and to any cultural taboos that may have become associated with the foods. In many parts of Ethiopia, the weaning-age child seldom receives specially formulated foods, but is gradually introduced to diluted adult food that may be nutritionally inadequate.

Immediately after birth and before the initiation of breastfeeding, the new-born infant is often fed butter. A small amount of water is also given, either mixed with butter or alone. The purpose of giving butter on the 1st day of the infant's life is to "open up its throat" or to "grease it" and to "get rid of dirty things" in the stomach. After this is done, breastfeeding can begin. Butter feeding continues, on average, up to 1-2 months of age; in some areas, it is continued even longer, mixed with a liquid made from fenugreek (Trigonella faenum graecum).

In one widespread practice, the child, from the age of a few days until he or she can walk, is given a liquid made of boiled fenugreek seeds. Sometimes this liquid is given on the infant's 1st day of life, in the belief that it will get rid of intestinal dirt. In some areas, it is the only supplementary food that can be given until the child is put onto adult food.

The most common way of preparing fenugreek as an infant food is to boil the whole seeds four to five times and discard successively each batch of boiling water; this is intended to remove the bitter taste. The infant receives the liquid from the last boiling. Although the seeds themselves contain 20-22% protein, the liquid made out of boiled seeds contains only 0.5% and is, therefore, nutritionally inadequate. The seeds are reused two to seven times - each extraction containing less protein. In some areas, fenugreek water is never used alone, but is mixed with milk, butter, or spices.

Depending on the availability of milk, which varies greatly from area to area, diluted milk and milk products are given from the age of 2-3 months and continued at least to 1-2 years of age; these feedings take place daily or several times each week. The milk is generally obtained from cows and, less often, from goats and camels. In urban areas, commercial powdered milk is also used.

Breastfeeding Pattern

The infant receives breast milk 2-3 days after birth. Although butter, fenugreek water, and diluted animal milk are given at an early age, breast milk constitutes the major part of the infant's diet for about the first 6 months; this is especially true in rural areas. Breastfeeding is generally continued, together with the provision of some cereal-based weaning foods, until the child is 2-3 years old. In certain communities, children receive only breast milk until they begin to eat adult foods.

According to studies conducted by ENI regarding the duration of breastfeeding, rural mothers breastfeed much longer than do their urban counterparts. A tendency was observed toward early cessation of breastfeeding in comunities where milk is relatively abundant and toward prolonged breastfeeding in areas where animal milk is scarce. In some cultural groups, the breastfeeding of male infants was recorded as being significantly longer than for female infants; this difference arises from the notion, prevalent in these groups, that boys need more strength than girls.

Grain-based Weaning Foods

The point at which infants begin the actual weaning process, i.e., the introduction of grain-based solid foods, is not the same throughout the country. It varies considerably with the ethnic make-up of the population, the degree of urbanization, and the socioeconomic status of the families. In general, however, infants in the rural areas start very late - from 8 to 12 months of age - whereas urban infants begin at about 5 months. The reason for late introduction in rural areas is sometimes said to be because of the unpleasant smell of the infant's stool. Furthermore, mothers believe that if children are introduced to solid foods before 6 months of life, they develop a swollen abdomen. Gruel, porridge, "fetfet," "ketta," and "dabo" are the popular traditional weaning foods used in most households (Table 1).

When mothers introduce solid foods to their infants, they traditionally give gruel made from a variety of cereals (Table 1). As the infant grows, porridge is given in addition to gruel, and both foods are given together until about the end of the 2nd year. When the child is about 2 years of age, "fetfet," "ketta," and "dabo" are given; soon afterwards, the child is introduced to an adult diet, consisting mainly of thin leavened bread ("injera") with hot sauce

Table 1. Major grain-based traditional weaning foods.

Weaning foods	Raw food items used
Gruel	Tef, sorghum, barley, maize, wheat, emmerwheat, and ensete
Porridge	Tef, sorghum, barley, maize, wheat, emmerwheat, and ensete
Fetfet[a]	Tef, sorghum, barley, maize, wheat, broad beans, chick-peas, field peas, and lentil
Ketta[b]	Tef, sorghum, barley, maize, wheat, ensete, and chick-peas
Dabo[c]	Tef, sorghum, barley, maize, wheat, and emmerwheat

[a] Thin leavened bread ("injera") mixed with sauce of legumes.
[b] Unleavened bread.
[c] Thick leavened bread.

("wot") made from legumes (split or ground, and spiced). Wherever available, butter is added to all these weaning foods. Either toasted or boiled whole cereals, legumes, or both, are also given as a small meal to older children who are able to chew it thoroughly.

Most of the traditional weaning foods are prepared from a variety of cereals, mainly "tef" (*Eragrostis abyssinica* - unique to Ethiopia), sorghum, barley, maize, and wheat. In the southern regions, however, infant diets are prepared mainly from false banana (*Ensete ventricosum*), which is the staple of the region.

The legumes grown include chick-peas, field peas, beans, and vetch. Unlike cereals, however, legumes are never used in the preparation of weaning foods. Their primary importance is to make sauce ("wot") that can be eaten together with the thin leavened bread as "fetfet." Except for onion, kale, and potato, fruits and vegetables are not widely used for feeding infants and young children, although a great variety of them are grown. A large percentage of children do not receive animal protein: their protein source is entirely of plant origin, the main part being derived from cereals. The concept of preparing infant foods from a mixture of cereals, legumes, and other food items has not yet spread through most areas of the country.

In some communities, taboos exist around certain foods, preventing their being given to infants and young children: honey is forbidden, in the belief that it will cause infants to stammer; eggs are believed to be a cause of intestinal parasites such as tapeworms; it is said that if children eat liver, they will lose their teeth; and because the heart is traditionally regarded as the centre of memory, it is believed that anyone who eats this food will be forgetful. There are also mothers who do not include certain cereals, such as sorghum and wheat, in their infants' diet because of the belief that these cereals will cause ascaris infection.

Dietary surveys undertaken in different parts of the country all show that the diets of infants and preschool children are seriously deficient in energy and often do not cover the child's need for calcium, iodine, iron, or most vitamins. The intake of protein is not only inadequate but also has relatively low biological value, as most of the total protein is from plant sources. According to these surveys, nutritious, easily consumed, digestible infant foods are almost nonexistent in most of Ethiopia.

Strategies for Improving Feeding Practices for Infants and Young Children

Organizations exist in Ethiopia for the introduction and reinforcement of developmental activities - activities that are geared toward a better quality of life for the people, especially for the rural masses. The following strategies are recommended to further these aims:

- All channels of communication - voluntary associations, religious leaders, schools, and youth, women, and peasant associations - should be used to inform the community about the value of breastfeeding. Women's associations should launch consciousnessraising campaigns in support of improved weaning habits. The training of community volunteers should be strengthened.

- Within the public sector, there should be a consistency of communication over the feeding of infants and young children. The promotion of breastfeeding and of appropriate feeding practices should be set within the context of overall maternal and child health-care practices, national food and nutrition policies, and primary health care.
- A more concerted national effort should be made to ensure the continuation of systematic epidemiological research.
- With regard to a promotion of locally available ingredients, more "demonstrative" strategies for training and education should be encouraged through health, education, and agriculture extension programs.
- Countries must recognize the need for subsidized weaning foods, so that these foods be made available to low-income groups. This can be achieved in part through the creation of low-cost production units at the peasant association level; such units could be planned and administered by the national organizations themselves. Government support must be given to practical and appropriate initiatives that address the following issues: to improve the nutritional value and hygienic standards for traditional and locally used weaning foods; to achieve a balanced diet for infants; to educate mothers in the appropriate feeding of children; and to facilitate the exchange of information on feeding practices for young children among countries in the region. The United Nations Children's Fund (UNICEF) could play a key role in the treatment of such issues.

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WEANING FOODS IN KENYA: TRADITIONS AND TRENDS

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Abstract *Groups of mothers and grandmothers (four to six women in each group) in six districts of Kenya held discussions that focused on the use of fermented porridges in feeding young children. Fermented cereal porridge is widely used and is prepared by first fermenting a slurry of raw cereal flour and water and then cooking the mixture. As reported in the discussions, attitudes toward the use of such porridges in child feeding vary: in Meru, mildly sour porridges are considered suitable for children from 6 months of age; in other districts, however, such porridges are not given until children are at least 1 year old. There was no report of germinated grain being used in the preparation of special foods for young children.*

Methodology

In 1986, final-year students of the Department of Home Economics at Kenyatta University College were asked to investigate methods of infant feeding in their home areas. The students were given a brief introduction to the methods of focus-group interviews and were asked to form small focus groups to discuss infant-feeding practices in their own communities. In each community, discussions were held with a group of mothers who had young children and with a group of grandmothers. The mothers were asked to discuss their current views and practices, and the grandmothers to comment on the ways in which these views and practices differed from those of the past. The students were asked to guide the groups toward a discussion of the following issues: introduction of complementary foods; preparation of porridges for young children; use of fermented porridge and of preparations involving germinated grain; and attitudes toward the feeding of sick children. Focus groups were conducted in the districts of Machakos, Kiambu, South Nyanza, Uasin Gishu, Meru, and Kakamega.

Findings

Feeding of Children under 4 Months

Breastfeeding was generally acknowledged by all the groups of new mothers to be the best way of feeding young babies. Other foods are introduced between 1 and 4 months: this supplementary feeding is said to take place when the "baby [is] not satisfied and still cries after breastfeeding," and when there is "not enough milk." The supplementary food commonly given at the time of these discussions was diluted cow's milk - a dilution of 1 part milk to 1 part water.

The discussions with the grandmothers revealed two interesting points relating to traditional early feeding practices: at one time, supplementary feeding was begun immediately after birth; and breastfeeding was continued until the child was 4 or 5 years old. The Meru grandmothers believed that breast milk alone could not satisfy newborn babies - that the diet of these babies had to be supplemented with something that would "hold longer" in the stomach.

The first solid food given to babies in Meru used to be "tuu tuu." This was prepared from a special variety of small, sweet banana, peeled and roasted in hot ashes. The outer layer was then removed, and the banana chewed well by the mother to ensure that it was thoroughly mixed with her saliva. This paste was then introduced into the baby's mouth with the mother's finger. Yams were prepared in a similar way. For slightly older children, "tuu tuu" was prepared in advance and stored in a special calabash fitted with a lid; older children could then feed this to the baby. In the discussions, the grandmothers described the preparation of "tuu tuu" for groups of babies. An almost identical preparation of masticated bananas was described by the Kiambu groups. The practice of masticating food for young children was at one time discouraged (principally by the missionaries) and is now considered to be a "dirty practice." The interviewers felt, however, that although they were reluctant to admit it, some mothers in Meru still prepare "tuu tuu" in the old way.

In parts of Kakamega district, very thin, plain sorghum or millet porridge used to be given to children immediately after birth; in other parts of the district, however, porridge was not given until much later, when the baby had begun to reach for food. The Meru grandmothers said that in the past, babies had been better nourished: "One could not see a baby's joints" (i.e., the babies were very fat!). Breastfeeding was continued for 5 or 6 years: "If another baby came, they could still breastfeed together, and it was only through the younger child scratching or pinching the elder one that the latter gave up."

In Uasin Gishu, the first supplementary food to be given to babies is fermented cow's milk ("mursik"). Milk is fermented in a cleaned gourd, the inside of which is rubbed with a special charcoal prepared from a type of wattle tree wood. The milk is then left to sour for up to 3 days. Milk that is very sour is not, however, given to babies. Bread dipped in tea is also a common supplementary food for young children.

Weaning

Respondents were asked at what point children require supplementary food (apart from cow's milk and predigested banana). The grandmothers offered three indicators for this timing: the child begins to reach for food that the mother is eating; the child grows a bottom tooth; or 6 lunar months elapse from the time of birth.

Most groups described a cereal porridge (usually unfermented) as the first weaning food. The most popular cereals are varieties of sorghum (*Sorghum vulgare*, Swahili "mtama"), finger millet (*Eleucine corancana*, Swahili "wimbi"), or bulrush millet (*Pennisetum typhoideum*, Swahili "uwele"). In Mbita, South Nyanza District, dehulled red sorghum used to be considered ideal, being preferred to white sorghum because "it gave children less stomach problems and made them grow plump." Nowadays, "wimbi" porridge is preferred because "the passage of stool" is easier than in children fed sorghum porridge. Over the last 30 years or so, maize has become increasingly popular as a porridge ingredient, either alone or mixed. Because, in Meru, millet is considered "too rich," maize is preferred for making porridge. In some parts of Kenya, dried cassava flour is added to a mixture of cereals.

In several districts, raw hens' eggs are added to the porridge. This technique has been widely encouraged by health workers: the addition of a raw egg to very hot porridge is a quick and convenient way of lightly cooking the egg. There might perhaps be a danger of the overzealous use of raw eggs with porridge that is not very hot: raw egg whites are known to contain avidin, a substance that complexes biotin; there may also be a risk of bacterial contamination from improperly stored eggs.

Fermented Porridge

The discussions revealed that fermented porridge is popular and widely consumed by adults and older children in all districts except Uasin Gishu. In most districts, fermented porridge is considered especially beneficial for mothers who have just given birth and for lactating mothers in general: the porridge is said to aid recovery and to help stimulate breast-milk production. In Meru district, it used to be believed that those lactations lasting 5-6 years were made possible by the mothers' consumption of fermented millet porridge. In several districts, bottled fizzy drinks, concentrated blackcurrent juice (available commercially), and cocoa are now believed to facilitate lactation.

In Meru district, fermented porridge was once a most prestigious food and is still a necessary part of important ceremonies, such as the payment of a dowry. It is said that to prepare good porridge, careful attention to cleanliness is important. Not all batches of porridge ferment well, and a woman whose porridge does not ferment well is scorned.

With regard to the use of fermentation for the preparation of weaning foods, it is only in Meru that fermented porridge is given, and here it must be "lightly fermented" or diluted. In the other districts, fermented porridge is considered bad for children under 12 months: it is said to cause complaints ranging from constipation, indigestion, and heartburn to diarrhea.

Preparation

All recipes described, except that from Uasin Gishu, were similar. A mixed cereal flour is first prepared - today in a hammer mill, but previously by hand grinding a wet slurry between two stones. (The latter method is still believed in Meru to make better porridge.) In hand grinding, careful attention is paid to particle size: the best porridges are obtained from a slurry that is neither too coarse nor too smooth.

The slurry is then heated (but not boiled) and the hot mixture transferred to gourds and left overnight. The clear liquid that separates out on top of the porridge is removed. The mixture is then stirred and is ready to eat. The washings from the pot in which the porridge has been cooked are used to make a thirst-quenching, acidic drink known as "rurima."

In Meru, no "starter" is used in preparing millet porridge; in preparing porridge from dehulled red sorghum, fermentation is assisted by the addition of raw, sweet-potato juice or the juice extracted from the leaves of a plant called "rung'oo." (The botanical name of this plant was not ascertained.)

Fermented porridge is also prepared from maize. The maize is first dehulled by wet pounding, then mixed with finger-millet flour and left to ferment up to 5 days. Portions of this fermenting batch are taken as required and cooked. In South Nyanza, cereal flour (a mixture of sorghum, millet, maize, and perhaps cassava) is mixed with warm water and left to ferment overnight. The mixture is then poured into boiling water and cooked.

A different method of fermentation is used in Uasin Gishu. A dough is made from raw maize flour and water and left to ferment in a covered pot for 1 week, during which a mould develops on the surface and the dough becomes very sour. This dough is broken up and added to boiling water to make a thick porridge that can be served with margarine, milk, or sugar. This porridge, known as "musarek ce kikimindili," is not given to children.

Use in Child Feeding

Fermented porridge was never reported as being prepared specifically for feeding young children. The porridge is prepared for the whole family, and children over a certain age are encouraged (or allowed) to eat it. In parts of Meru and Kakamega, infants from about 6 months are encouraged to eat fermented porridge; in the other districts, it is not believed to be a good food for children under 1 year of age; some respondents stated that children should be considerably older - over 5 years - before being given the porridge.

Views of Consumers

Because it is tastier and can be eaten without sugar, fermented porridge was reported by most groups to be preferred over plain, untreated porridge. The sweetness of fermented porridge was important in the old days when cane sugar was unavailable; sugar or sugar and lemon juice are modern flavourings, as is tea. The Kakamega group reported an additional advantage in the good storage capability of fermented porridge.

Three disadvantages were mentioned: time needed for preparation; unavailability of ingredients; and potential problems (heartburn, indigestion, constipation, and diarrhea) for young children eating fermented porridge.

Influences on Use

The Kakamega groups reported that the predominant church, the Society of Friends, had previously discouraged the preparation of sour porridge because of the belief that this porridge contained alcohol. Earlier discussions in Meru had already revealed a similar attitude on the part of the missionaries. These difficulties, however, were not reported by any of the other groups.

Although sour porridge was once extremely popular in the Kakamega district, it is now prepared only rarely. Very little sorghum or millet is grown in this area, these grains having been almost totally replaced by maize. People in this district are said "to lack the will and the interest" to prepare traditional fermented porridges.

Germinated Grain

All groups were asked to mention any knowledge of the use of germinated grain in the preparation of nonalcoholic foods. No specific practices were mentioned in any district. In Kakamega, the solids filtered off during the preparation of opaque "bussaa" beer are mixed with cereal flour and used in the preparation of a porridge that is said to be extremely palatable.

Conclusions

People in many parts of Kenya prefer the sharp, acidic flavour of sour, fermented cereal porridges. (Lemon juice is used to make nonfermented cereal porridges more palatable.) Although fermented porridges are still widely consumed in rural areas, their popularity appears to be declining in favour of supposedly modern alternatives, such as tea or fizzy soft drinks.

Except in the Meru district, sour, fermented cereal porridges are not routinely given to children under 1 year of age: although these porridges may at one time have been fed to infants, fermentation is currently associated with the production of alcohol. Considerable efforts would be required, therefore, to popularize or to reintroduce fermented porridge as a food that is suitable and safe for young children.

FOOD PROCESSING IN UGANDA WITH SPECIAL REFERENCE TO INFANT FEEDING

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Abstract *A current survey in Uganda is examining the processing of several foods, among them bananas, cassava, maize, milk, millet, and sorghum. The processing methods under study include sun drying, fermentation to produce sour porridges or alcohols, detoxification of certain toxic cassava species, and the addition to foods of souring fruits. The resultant improvements are discussed, together with the value of processed foods, especially those that are fermented or germinated, in infant feeding. Particular attention is given to problems associated with weaning and with the feeding management of sick children. Preliminary findings suggest that the use of locally available foods in the feeding of sick infants prevents further deterioration of their nutritional status. Protein energy malnutrition (PEM) in Ugandan children is now believed to be related to improper weaning practices; among other consequences of these practices are the infectious and noninfectious diarrheas that exacerbate an already dangerous situation. It should be possible, in developing processing techniques, to take advantage of the wealth of traditional experience with which Ugandans have met the nutritional problems of infants. Agriculturally, Uganda has the potential to produce enough food for its population; to alleviate the problem of infant feeding, therefore, these rich, natural food resources should be more efficiently used.*

Uganda's nutritional problems have long been recognized, and much research has been undertaken to find causes and possible solutions. Today, however, about 30% of preschool children in Uganda suffer from chronic malnutrition (RTI 1984). This situation will remain unchanged until appropriate intervention measures are identified. In her historical review of Uganda's nutritional problems during the pre- and post-colonial eras, Sserunjogi (1985) found that the dominant causal factor for protein energy malnutrition (PEM) in Ugandan children was not a shortage of available food, but rather the existence of improper weaning practices.

The weaning period presents many nutritional and developmental problems. This critical period is associated with a high rate of infection, particularly of diarrhea, that eventually precipitates the condition of malnutrition. The infant's breast-milk diet guarantees anti-infective protection, ease of digestibility, and ready availability. Foods are often given that are difficult to digest and that are therefore poorly utilized by the fragile digestive system of the young infant; these foods are, moreover, often prepared, stored, and fed to the infant under conditions that are only marginally hygienic. The availability of appropriate weaning foods that would ensure adequate nutritional intake depends both on regional and on domestic food supplies; the nutritional status of weaning infants also depends, however, on the manner in which these foods are handled.

Problems associated with weaning can also be traced to inattention to maternal welfare. The importance of maternal nutritional status during pregnancy and during lactation must not be underestimated: good nutritional status ensures not only adequacy of lactation, but also appropriate timing for the initiation of weaning.

Prospects for local food production, eating habits, and urbanization are all factors that are likely to influence traditional weaning patterns. This paper briefly discusses preliminary results from an ongoing study in Uganda that is attempting to identify ways of improving the health and nutritional status of weaning infants. This study is evaluating attitudes toward weaning foods and the ways in which they are used, with particular attention to the use of fermented foods in the management of diarrheal disease. Careful consideration of traditional practices (practices that are usually based on generations of practical experience) often suggests important and appropriate solutions that are more easily accepted by mothers than the "modern" techniques.

Agricultural Potential of Food Crops

Uganda is a rich agricultural country: about 70% of its land area is suitable for agricultural activities. The last agricultural census was carried out in 1963-64 (Uganda 1965). Because of a lack of comprehensive data on subsequent changes in farming systems, the analyzed data of this census have regularly been used to give a general picture of the food-production characteristics of the past, as they compare with the recent agricultural situation (1971-85 yield estimates). Because of an improvement in the provision of agricultural services, there was, at the time of the earlier census, some improvement in farming practices; this momentum was lost, however, during the political events that occurred between 1971 and 1985, and it is argued that domestic production has now fallen to the 1963-65 levels (Muthee 1987).

Although the entire population of Uganda experienced conditions of social disruption for many years, the country did not undergo serious food shortages between 1971 and 1985. This can be attributed to the rich natural resource base and to the diversity of agricultural production in most areas of the country. Even when the standard of technology was low, adequate rainfall and fertile soils helped to maintain sufficient food output; although the agricultural sector producing cash crops collapsed, the sector producing subsistence crops thrived. Domestic food crops afterwards became important cash crops, and now sales of small domestic surpluses contribute more than one-third of the rural household cash income (Bank of Uganda 1987). Were the management of the food-crop sector to improve, Uganda would have definite potential for increased food production. Allowing for such an improvement, the government projects a surplus yield in the food-crop sector for the 1986-90 period.

In summary, the food-crop sector in Uganda has, during the last 15 years, produced only enough for broad self-sufficiency. So that the country may be self-sufficient in food production and have surpluses for export, the government has indicated that the food-crop sector is in future to be given the highest priority (Uganda 1987). It remains to be seen whether the struggle for an exportable surplus will allow the agricultural sector to satisfy the needs for domestic food consumption.

Nutrition Problems in Uganda

Those segments of the population most severely affected by nutritional problems in Uganda are children, mothers, the elderly, the urban poor, and the displaced. The most prevalent nutritional deficiency disease is PEM, clinically manifested as kwashiorkor or marasmus, often associated with anemia.

Protein deficiency in the traditional Ugandan diet was for many years believed to be the cause of kwashiorkor. The predominance of a vegetarian diet with high carbohydrate content was blamed for the low protein intake. It was recommended, therefore, that output of animal food products be increased.

In the early 1960s, nutrition rehabilitation centres were established in which nutrition education would be used to persuade mothers to feed their young children with foods high in animal and vegetable protein. Mothers were considered ignorant about the nutritional needs of their children and were blamed for misusing the locally available foods.

In the mid-1960s, a new food product was introduced to the Ugandan infant diet: soy products - to be promoted as locally available, high-protein processed foods - were introduced for the low-income consumer (Harrison 1972). The technology of multimixes came at about the same time; this technology was intended to help balance local diets and thus improve the essential nutrient intake for infants.

Around this time, a new perspective opened on the problem. Bennett and Stanfield (1972) found that marasmus occurred in areas with low total food intake, despite the fact that the quality of the diet in these areas was adequate. This line of research, pursued by Rutishauser and Frood (1973), suggested that the fundamental problem in infant feeding was not in fact protein deficiency, but rather an inadequate intake of energy: not only had most of the foods a low fat content, but the traditional cooked staples were high in bulk, meaning that the number of meals consumed were fewer than was desirable. It was recommended, therefore, that diets include traditional relishes made from groundnuts and sesame seed mixtures; in this way, energy density would be increased and the bulkiness of the diet reduced (Church and Doughty 1976; McDowell 1976; Goode 1982). By means of this strategy of high-energy intake, the local, traditional Ugandan diet, with its low-protein intake, would be protected.

Frequency of feeding depends on several factors: availability of adequate cooking fuel; distance of the water source from the home; time required by mothers in preparing extra meals; and economic constraints. The typical Ugandan family has two main meals per day - the morning meal and the evening meal. This trend cannot change without disrupting the local pattern of life; measures that encourage change must, therefore, encompass an understanding of these factors.

Rutishauser and Whitehead (1974) found that frequent episodes of illness, especially of diarrhea, take place during the weaning period. These episodes cause lowered appetite, which in turn limits food intake. Moreover, although the sick children have nutritional needs that are higher than normal, proper food utilization is made more difficult by the illness itself. Appropriate intervention is urgently required in the feeding management of sick children; only in this way will they be protected from further deterioration in nutritional status.

When we examine the many causes of nutritional problems, we must not overlook poverty and low purchasing power. As long as the standard of living remains low, especially in the urban areas, nutritional problems will continue to exist.

In the past, much criticism of the African diet has been based on the high carbohydrate content of the foods. In view of the fact that, over the years, estimates of nutrient requirements have been revised downward, we should acknowledge that these bulky staples are a major source of total nutrient intake in the local diet and that many people will continue to survive on them. There is, however, a need to improve on this diet of bulky staples: traditional processing methods could be employed to facilitate the assimilation and utilization of valuable nutrients in the food.

Infant Feeding Practices in Uganda

Mothers are currently taught that all babies, until they are 4 months of age, can grow well by feeding solely on breast milk; although the teaching includes the fact that very few babies can continue to grow properly if they receive only breast milk after the age of 6 months, many of the mothers in the survey started supplementary feeding as early as 1 month or as late as 12 months of age. The fact that breastfeeding may continue for up to 2 years does not solve the problems created by late initiation of supplementary feeding.

A number of reasons are given for early supplementary feeding or cessation of breastfeeding: insufficient milk production by the mother; the onset of a new pregnancy; the appearance of the infant's teeth; the mother's poor health; the mother's return to work; and, most commonly, the decision that the child is big enough that he or she may stop.

During the period of supplementation, the foods most commonly used are: diluted cow's milk; porridge made out of maize, millet, or sorghum flour; vegetable stews; and tea. This period is followed by one in which the child partakes of the typical family diet. Because, in this situation, young children traditionally obtain their meals whenever the mother is ready to have hers, the concept of frequent feeding for infants becomes difficult to implement. Most of the foods that can be prepared for infants have a short shelf life, and mothers rarely have enough time to prepare extra meals for their children. Sanitary conditions are poor, especially in urban areas; water supplies are inadequate; and a great deal of cold leftover food is consumed. The resultant bacterial food contamination leads to diarrheal diseases in the children.

Traditional Food-Processing Techniques

The foods commonly processed include millet, sorghum, bananas, maize, milk, and cassava. These foods are usually processed for consumption as cold or hot porridges, or for alcoholic drinks. It has traditionally been found that processing brings the following advantages: prolonged shelf life, improved flavour, better texture, easier grinding, and stimulation of the appetite; processing also allows detoxification of toxic cassava species and facilitates the preparation of butter fat and the making of beer.

Cassava

Cassava is processed in different ways by different cultures. Fresh cassava roots are soaked in water ponds or pots and left to ferment for 3-4 days; alternatively, these roots may be peeled and then heaped or piled in the house or in a hole in the ground, then thoroughly covered with banana leaves and left to ferment for 3-4 days. Eventually, the mould is scraped off, and the roots are broken into pieces and sun dried. The dried cassava is normally stored in baskets. With its susceptibility to insect infestation, cassava cannot be stored in a powdered form for long; it is therefore ground or pounded into flour only when needed.

Cassava can also be processed by sun drying the roots without prior fermentation. In this form, the dried cassava roots can be stored in granaries for a longer time than can the fermented type. In some areas of Uganda, particularly in the northwest, the cassava root is very bitter and contains high levels of cyanide toxin; this cassava must be processed by the first method - that is, by fermentation, followed by sun drying.

Even for the nontoxic cassava, the processing that involves fermentation is said to be preferable: this method makes the root much easier to grind into flour; it also provides a better texture for bread-making; and the dishes cook much more quickly, thus saving on cooking fuel and time. For bread-making, fermented cassava flour is mixed with either nonfermented millet, sorghum, or maize; the choice of grain depends on cultural preference. This main dish is prepared once or twice a day for the family meal.

Except in the northwestern regions, where, in times of abundant supply, it is used as a breakfast porridge for children, cassava flour is not used for porridge as often as are the cereal flours. In northwest Uganda, where cassava is consumed only in fermented form, cassava porridge is used mainly when there is diarrheal disease: it is believed to help stop the diarrhea and to restore the physical strength of the sufferer. The porridge, when cooked, is smooth in texture, nonfilling, and has a pleasant, appetizing flavour for the invalid. In the eastern region (Teso district), the thick texture of nonfermented cassava porridge is believed to help stop diarrhea and is therefore preferred to the fermented types.

Millet and Sorghum

Millet and sorghum can be processed into sour porridge ("bushera") and alcoholic beverages in the following way: the dry grain is soaked in water for 1 day to initiate germination; the wet grain is then mixed with ash and left to germinate further for 2 or 3 days, covered with banana leaves; eventually, the grain is sun dried and ground into fine flour.

"Bushera" is commonly processed in the southwestern region of Uganda. The dry, germinated sorghum flour is boiled into a porridge that can be drunk hot or cold. "Bushera" can also be prepared by boiling ungerminated millet flour into a thick porridge; freshly germinated millet flour is then added to sweeten the porridge and to lower its viscosity.

"Bushera" can be taken at any time of the day, and can be kept for 3-4 days before it becomes a strong alcoholic beverage. Very young children can safely consume "bushera" within the first 2 days before it becomes sour; because the sour type of "bushera" is believed to cause stomach upset in very young children, it is not given to infants under 8-12 months. In most of the southwestern region, "bushera" is drunk instead of water or tea. It is said to be very palatable, especially for invalids, and is believed to stimulate the appetite.

In other areas of the country, the nonfermented (or germinated) millet or sorghum porridge is commonly used as an early weaning food. (Except for beer making, the practice of fermenting millet is nonexistent in these areas.) Nonfermented millet and sorghum porridge can be made sour by the addition of tamarind (traditionally known as "kiti" or "pitei" in northwest Uganda and as "chwa" in eastern Uganda), lemon juice, or herbal mixtures. The acidic water from these fruits or vegetables is used to boil the porridge, leaving it with a low viscosity, a smooth texture, and a distinctly acidic flavour. Porridge is often soured to improve the flavour and to make it palatable when there is no sugar; it is not, however, recommended for very young children. Because this soured porridge is believed to improve the appetite, it is very popular during convalescence.

Milk

Sour milk is most popular in pastoral areas, mainly in the western and eastern parts of the country. Sour milk is a staple food for the whole family, with the exception of very young infants of less than 6-8 months old. The "ghee" or butter fat, obtained through the process of churning the milk, is one of the main constituents of relishes and sauces, especially for the lactating mother; the energy intake of the family diet is thus improved, both for the children and for the adults. (We should bear in mind the fact that young children often nibble on whatever the mother is eating, provided it is soft.)

Because sour milk is believed in some areas to cause diarrhea, it is not always a part of the staple diet.

Bananas

Certain types of sweet bananas are processed mainly for alcoholic drinks. A nonalcoholic drink can be made by crushing the fruit with spiky grass to extract the juice. When the beverage is within the 1st day of preparation, it is quite safe to give to children. It is sometimes added to boiled porridge when there is no sugar available. Banana juice ferments into alcohol within 2-3 days and is then unsuitable for consumption by children.

Seasonal Availability and Use of Land

Patterns of consumption depend on many factors. Most people in rural communities know, for example, those seasons suitable for the planting and harvesting of specific food crops. Cassava is a perennial food crop and is, therefore, available all the time. The roots of the toxic species must, however, remain in the soil for not less than 2 years; availability depends, therefore, on whether the crop is mature enough for consumption. For proper agricultural planning to take place, there must be sufficient land available for crop rotation. The adequacy of the food supply depends, therefore, on the amount of land available for agriculture.

During the harvesting season, when there is enough food to guarantee a surplus, the consumption of sorghum and millet, sour porridge, and cassava porridge is much more common. Children can then have porridge more often during the day, in addition to the family meals.

Most people in rural areas are subsistence farmers, often working for long periods in the fields, away from their homes. Because sour porridge can be safely carried to the fields, it is popular as the main food of the day; it is also the first meal taken when people return home after a heavy day's work. Not only is it a digestible and nutritious food for all types of people, but it is also cool, refreshing, appetizing, and has a lengthy shelf life; these factors combine to make it an extremely valuable food.

The low standard of living has made people turn away from traditional eating patterns. It is cheaper to depend on household food supplies for the family's main meals and on porridges for supplementary snacks or meals for the children. Food crops in most areas have become a source of cash income, and the people tend to sell most of what they grow in surplus. There is, therefore, no surplus food stored in granaries; in times of household food shortages, most families depend on purchased food. In those times, food is often not available for preparing extra meals for infants.

Certain methods of preparation are not acceptable in some religious sectors of the population. There is a taboo against alcohol in Muslim communities; caution must, therefore, be exercised when advocating any method of preparation that might, with time, make a food or beverage alcoholic.

In the ongoing study, the mothers interviewed to date have given lists of foods that they would either use or avoid during their children's illnesses. The following are among those foods widely recommended for sick infants: germinated and nongerminated sorghum porridge, fermented and nonfermented cassava porridge, and nongerminated maize porridge. Millet porridge and millet bread are avoided completely, as are sour milk, potatoes, eggs, boiled beans, peas, fruit, and porridges soured with fruit or vegetables. This paper cannot give in detail the reasons behind these beliefs. There should be some investigation into the effects on child feeding of those situations in which "avoided" foods are the only foods available.

Conclusions

The benefits obtained from fermented or germinated food products have been exhaustively discussed in the literature (Tomkins et al. 1987). Among these benefits are: improved nutritional value, better storage capability (ensuring ready availability of the feeds), improved digestibility because of microbial and biological reactions, and low pH content, thought to prevent bacterial growth. The most important problem to be identified regarding the use of traditionally processed foods for infant feeding may be that of inadequate household food supplies; this inadequacy can usually be traced to economic and social constraints. To guarantee infants an adequate provision of these processed foods, families must grow a surplus of food not only to supply their domestic needs but also to generate cash income.

Although they may not know the scientific theory behind the technology, the indigenous people of Uganda do appreciate the value of processed foods. They are often aware of what is suitable for infants, and what can be used in such circumstances as illness and convalescence; it may nevertheless be possible to recommend changes that would further the solving of specific, well-defined problems in infant feeding, such as the feeding of a sick child or the management of a child with acute diarrheal disease.

The technology of germination and fermentation has a significant role to play in solving the problem of inadequate weaning practices. Early weaning affects the maintenance of adequate milk production; cow's milk, diluted with possibly contaminated water, appears to be the most common supplement given during this early weaning period. There is a need for a safe weaning food that can supply the nutritional needs of all stages of the infant's development. There is also a need to determine the "safety margin" of fermented foods as weaning foods: these foods offer some protection against the common disease pathogens of infants, usually present through poor sanitary conditions.

In Uganda, production of food crops is promising. A fuller understanding of the benefits that accrue from the use of local, traditional technologies will help in promoting existing local food resources.

Finally, it should be remembered that if any achievements in child feeding are to be appreciated by the local population, traditional cultural practices must be respected.

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WEANING FOODS IN RWANDA AND THE POTENTIAL OF SPROUTED SORGHUM

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Abstract *The persistence of child malnutrition in Rwanda is attributed largely to a lack of time and money on the part of the mothers. In the northern parts of the country, women spend nearly 10 h in the field and so can prepare the family food only once or twice each day; this food is usually high in bulk but low in nutritional value and is, therefore, inadequate for feeding young children. At present, the high nutritional value of sprouted or fermented flours is recognized neither by the mothers nor by the nutrition personnel who educate them. Although traditional fermented porridges, made from corn or cassava, are consumed in some regions, they are not universally regarded as good weaning foods. Sprouted sorghum flour is used in most households, not to improve the plain porridge of unsprouted sorghum, but for making beer. The United Nations Children's Fund should, in its 5-year program of cooperation with the government of Rwanda, support further research on the use of sprouted or fermented sorghum flour in weaning food.*

Over the last 10 years, the situation with regard to child malnutrition in Rwanda has not greatly improved. Because mothers have neither the time nor the money to prepare special meals, their young children receive complementary foods that are nutritionally inadquate. Particularly in the northern regions of the country (Ruhengeri, Gisenyi, and Byumba), women spend nearly 10 h/day in the fields; with little time left to prepare food, they generally cook only once, preparing sufficient quantities for the entire day. Their young children are, therefore, fed the stodgy adult diet based on tubers (potato, cassava, and sweet potato) and beans, both of which are difficult to digest. Moreover, because this food is served only once or twice daily, the quantity consumed by the child does not provide adequate nutrients and energy. Also of significance is the fact that the child's portion, kept at a moderately high temperature throughout the day, is subject to bacterial contamination that can lead to diarrheal infections.

It is logical, therefore, to look for infant foods with the following characteristics: adequate energy content, resistance to bacterial contamination, and ease of digestibility and of preparation. Porridges based on sprouted or fermented sorghum flour and on other traditional fermented foods may answer these needs.

Traditional Fermented Porridges and Weaning Foods

Fermented maize porridge ("umutsimawibigori") is made from maize that has been dried and stored for gradual use over the year. To initiate fermentation, the maize is left to soak in water for 1 week. The kernels are then gently dehusked by pounding and the inner grains are dried for several hours. These grains are pounded together with some crumbly stones ("imonyi") that facilitate grinding and sifted to produce flour. Mothers prepare the porridge by gradually stirring hot water into the fermented maize meal with a wooden spatula until the desired consistency is reached. Porridge of fermented maize meal, accompanied by a green sauce or other foods, is also eaten by adults.

Fermented cassava porridge, despite its lower nutritional value, is an important food during the between-harvest period when little else is available. Most rural families prepare fermented cassava flour ("umutsimawimyumbati") by leaving the tubers to soak for 4-5 days in slightly muddy water until they ferment. The fermented cassava is then dried in the sun for 1-2 days, after which it is peeled, dried again, and pounded into a powder. This flour is made into a porridge by stirring it into boiling water. The family eats the porridge with haricot beans, peanut sauce, or green sauce with peanuts.

Mothers often give their children diluted sorghum porridge ("igikoma") to drink. A preliminary investigation of 20 samples of sorghum porridge that mothers had brought to nutritional centres in Sovo/Butare showed that the porridges contained a mean of 7.44 g of solids per 100 g wet weight (standard deviation, 2.4; range, 3.9-14.6). This would result in a mean density of 0.26 kcal/g of porridge. This soft drink is also given to lactating women who are breastfeeding. The children also drink fresh banana juice before it is fermented.

In banana-growing regions such as Kibungo and Cyangugu, boiled and mashed plantains may be mixed with crushed peanuts ("umububi") or with haricot beans (usually eaten unshelled in rural areas) and given as a weaning food to children who are about 1 year old or to those with teeth. Infants already able to hold an object are given ripe bananas to eat. Ripe, sweet bananas ("umuneke") are considered fit for women and children but not for adult men.

Banana beer, using roasted sorghum seeds to initiate fermentation, is very popular among rural families and constitutes a major household expenditure. In such households, one usually finds the large reserve calabash ("igicuma") and the smaller one ("agacuma") (fitted with its traditional spout or "umuheha") that is passed to each person in turn. As the calabash makes its rounds, it is not unusual for children to be given a taste of the beer by their mothers. If the child is very young, the mother sips some beer into her mouth and spits it into that of the baby. Older children drink directly from the spout. Among these families, it is believed that strong drink dispels discomfort and calms worms ("gucurica inzoka").

The changes that occur in germination and fermentation are produced by the enzymatic activity of microorganisms during the metabolization of sugar; this process is responsible for the higher energy content of fermented foods. In addition, the pH of fermented foods inhibits the development of those pathogens that cause diarrheal diseases. Porridges made from sprouted or fermented cereals may contain more energy and vital nutrients per unit volume than those made from unsprouted or unfermented grains.

Preparation of Sprouted Sorghum and Fermented Sorghum Flour

Sprouted and fermented sorghum flours are prepared by most Rwandan families in the course of making sorghum beer. Three to four pitchers of homemade sorghum beer are always available in Rwandan households to quench the thirst of those who have been working in the fields. When marriage is proposed, the future husband's family brings along one pitcher of sorghum beer and one of banana beer; because sorghum beer is usually a woman's drink and banana beer a man's, this custom symbolizes the union of man and woman. During the celebration of the start of the rainy season in August, children offer their parents a pitcher of sorghum beer to show their appreciation. The beer is also drunk at wakes. When a person is given a cow, sorghum beer is offered in return as an affirmation of friendship.

The preparation of sorghum beer in rural households is as follows. The sorghum is soaked in water in a wooden trough for 2-3 days, after which it is spread on a mat and left for 1 day, covered with green banana leaves. It is then mixed with the ashes of dried banana leaves (to initiate germination) and dried. The young shoots are carefully removed, and the kernels sifted out. These kernels are milled with a grindstone into a brownish flour that, mixed with water and boiled, produces a sticky porridge. The porridge is diluted with water, left to cool, and poured into pitchers with malted sorghum flour and yeast from banana wine. The beer is fermented at room temperature and is ready in 12-23 h.

Studies on Sorghum

Although figures on home consumption are not yet available from the National Survey of Rural Household Income and Expenditure (Rwanda 1986b), it is, nevertheless, useful to look at the place occupied by sorghum in the annual household expenditure of Rwandan families (Table 1). As can be seen, sorghum has an important place in Rwandan households, both as a cereal and as a base for drinks.

According to the 1984 National Agricultural Survey (Rwanda 1984), the first agricultural season in 1984 yielded 28,252 t of sorghum, harvested from 189,443 planted fields, i.e., 149 kg/field. Millet appears to be less widely cultivated than sorghum. The survey also indicated that Byumba, Ruhengeri, and Gisenyi are the major sorghum-producing areas. Women are the primary agricultural workers in these northern regions. In sorghum cultivation, the men may assist in clearing the land, but it still remains for the women, often with small children strapped to their backs, to plant, hoe, reap, and dry the grain. Men may also take a hand in threshing, but winnowing and storage in the family granary ("umutiba") is again the women's responsibility.

Table 1. **Annual household expenditure on foodstuffs in Rwanda.**

Foodstuff	Average annual expenditure (RWF)[a]	Percentage of budget
Cereal grains		
Sorghum	280	2.6
Rice	300	2.8
Corn	75	0.7
Others	63	0.6
Subtotal	718	6.8
Tubers and bananas		
Cassava	356	3.4
Sweet potatoes	272	2.6
Potatoes	358	3.4
Bananas	80	0.8
Others	32	0.3
Subtotal	1098	10.4
Legumes		
Haricots	1485	14.1
Peas	80	0.8
Peanuts, etc.	69	0.7
Subtotal	1634	15.8
Fruits	179	1.7
Animal products	1466	13.9
Drinks		
Banana beer	2576	24.4
Sorghum beer	696	6.6
Primus beer	808	7.7
Others	90	0.9
Subtotal	4170	39.5
Other foods		
Palm oil	449	4.3
Salt	491	4.7
Sugar	104	1.0
Others	244	2.3
Subtotal	1288	12.2
Total	10553	100.0

[a] In 1988, 80 Rwanda francs (RWF) = 1 United States dollar (USD).

In 1977, a team from the Rwandan Institute of Agricultural Science (ISAR) comprising Emmanuel Twagirumukiza, an agronomist specializing in microbiology, and Charles Iyakaremye, a chemical engineer specializing in industrial agriculture, wrote: "In Rwanda, sorghum is the principal cereal, cultivated in all regions. Many local varieties exist, of which the most common are 'kebo' (SVR 157), 'nyiragimoli' (SVR 101), and 'karuguma'." From 1975 to 1984, sorghum produced 121,100 t at 149 kg/field, with an average yield of 9-11 q/ha (1 q = 100 kg).

The ISAR team noted that homemade fermented sorghum wort (used to make a beer based on sprouted and fermented sorghum flour) has a higher nutritional value than that of sorghum porridge (made with nonfermented wort): numerous yeast cells develop in the wort, producing animal proteins and vitamins, especially those in the B group. In 1977, ISAR's Technology Division worked on improving the suitability of sorghum for breadmaking; they went no further, however, in studying its nutritional potential. In another study in 1982, Jo Laure, a nutritional expert of IMSEA (Institute of Statistics), found that, on average, infants in Nyabishongo were weaned at 12 months; 76% of the mothers reported giving sorghum as the traditional weaning food.

World Bank consultant Dick Heyward, who worked with the Centre for Nutrition Training (CNFR) in Ruhengeri from February to April 1985, conducted trials on the taste acceptability to children of sprouted and unsprouted sorghum porridge enriched with haricot or pea flour. The trials, involving 28 children and their mothers, took place at the Applied Nutrition Centre (CNA). CNA workers prepared four different porridges before the mothers arrived: sprouted sorghum with shelled haricot beans, unsprouted sorghum with shelled haricot beans, sprouted sorghum with peas, and unsprouted sorghum with peas. In this week-long experiment, separate groups of mothers rated the porridges according to taste, smell, etc. The mothers then fed the mixtures to their children, whose reactions were noted by CNA personnel.

The tests concluded that because of their slightly sweet taste, porridges based on sprouted sorghum flour were preferred. The more aromatic porridges made with roasted sprouted sorghum were the favourite. The results of this experiment were unfortunately not published. To date, no effort has been made to introduce sprouted sorghum as a weaning food.

The 1986 National Nutrition Survey, conducted on 2995 children, provided the information contained in Table 2 on the status of children up to 5 years of age (Rwanda 1986a). The average length of time for which children were breastfed was 18.6 months. Out of 1332 children under 24 months of age, only 424 were fed porridge. In over 46% of households surveyed, porridge was prepared less than 7 times per week. Daily preparation of meals was as follows: 1 meal/day in 292 households (14.6%), 2 meals/day in 1486 households (74.5%), and 3 meals/day in 218 households (10.9%).

A study on the feeding of children aged 6-24 months, conducted by the United Nations Children's Fund (UNICEF) and the National University of Rwanda (UNR), is currently in progress. A random selection of 100 cards containing data taken in one sector of Butare showed the

Table 2. Distribution (%) of children aged up to 5 years on the basis of weight-for-age, 1986.

	Child's age (months)					
	0-12	13-24	25-36	37-48	49-60	Total
Number of children	650	682	684	559	420	2995
Ratio (weight/age)						
Above 80%	82.2	69.3	73.2	68.2	66.9	72.4
Below 80%	17.8	30.7	26.8	31.8	33.1	27.6

frequency with which complementary foods are given to young children (Table 3).

Conclusions

Sorghum is found throughout Rwanda. Nearly all rural Rwandan families prepare sprouted sorghum flour that is later fermented to make beer. This flour - one that produces a higher energy porridge than unsprouted - is, therefore, available in most households; mothers need only be encouraged to use it for preparing weaning foods for their young children. To our knowledge, however, no serious study has been undertaken in Rwanda on the use of fermented sorghum porridge, either as a weaning food or as a food for children who, having been ill, are anorexic. At present, neither the flour's energy value nor its resistance to spoilage is recognized by mothers or by nutrition personnel.

Large-scale studies should be conducted to investigate those problems that interfere with the year-round feeding of sprouted sorghum-based foods to young children. Included in such studies would be the palatability of the flour and its effectiveness in preventing malnutrition. Many unknowns still exist with respect to the use, particularly for infant feeding, of sprouted sorghum and traditionally fermented foods. It is important that an undertaking to support

Table 3. Frequency of complementary foods given to children aged 6-24 months, 1987.

Age of child (months)	Number of children	Number of meals per day apart from breastfeeding							
		0	1	2	3	4	5	6	Over 6
6-8	17	2	-	4	6	4	1	-	-
9-12	17	-	-	3	6	2	6	-	-
13-18	29	-	-	3	6	13	3	4	-
19-24	17	-	1	2	6	5	3	-	-
Over 24	20	-	-	1	4	11	4	-	-
Total	100	2	1	13	28	35	17	4	0

further research on sorghum and infant feeding be included in UNICEF's 5-year program of cooperation with the Government of Rwanda; this program is operating concurrently with the country's fourth 5-year plan.

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OBSERVATIONS ON CHILD GROWTH AND WEANING IN ZIMBABWE[1]

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Abstract *Ad hoc discussions held with several elderly people living in eastern Zimbabwe brought to light weaning practices that are no longer widely used. The information obtained about these traditional practices revealed that bulk preparation of sour porridge saved time, fuel, and labour; that herbs, when stored with the porridge, had a preservatory effect; and that sweet potato flour could sweeten the porridge while increasing its energy density. It is recommended that, on the basis of this information, more research be conducted into traditional weaning practices.*

Malnutrition in children under 5 years of age has been a major concern in many developing countries. Using weight-for-age as an indicator, surveys have been carried out to determine the prevalence of malnutrition in Zimbabwe (UNICEF 1980); these surveys have shown a decline in the rate of malnutrition from 50% to 10-20% (clinic-based data from the Zimbabwe national health information system for January-June 1987); the data excludes children under 5 years of age who do not attend well-baby clinics. Despite this apparent improvement, the 1985 Household Survey (unpublished) shows that there is still a great deal of work to be done to reduce malnutrition associated with the weaning period (Figs. 1-4).

Although malnutrition has many causes, the 1985 survey results appear to confirm the role played by inappropriate weaning practices in the etiology of malnutrition among children under 5 years of age. This paper is intended to initiate discussion and to map out a strategy to combat infant malnutrition; of primary importance to this strategy is the initiation of research into, and improvement of, traditional weaning methods.

Traditional Weaning Methods

In the informal, ad hoc interviews held with elderly people (60 years and over) in Manicaland Province, the general feeling was

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[1] This paper was presented by L. Mushonga, Ministry of Health, Causeway, Zimbabwe.

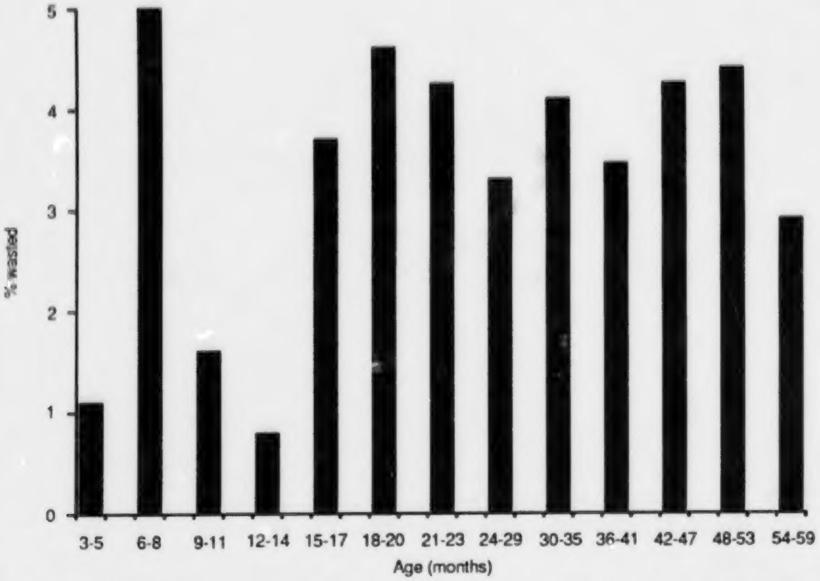

Fig. 1. Prevalence of wasting, in communal areas only (% of children with standard deviation score for weight-for-height of less than -2).

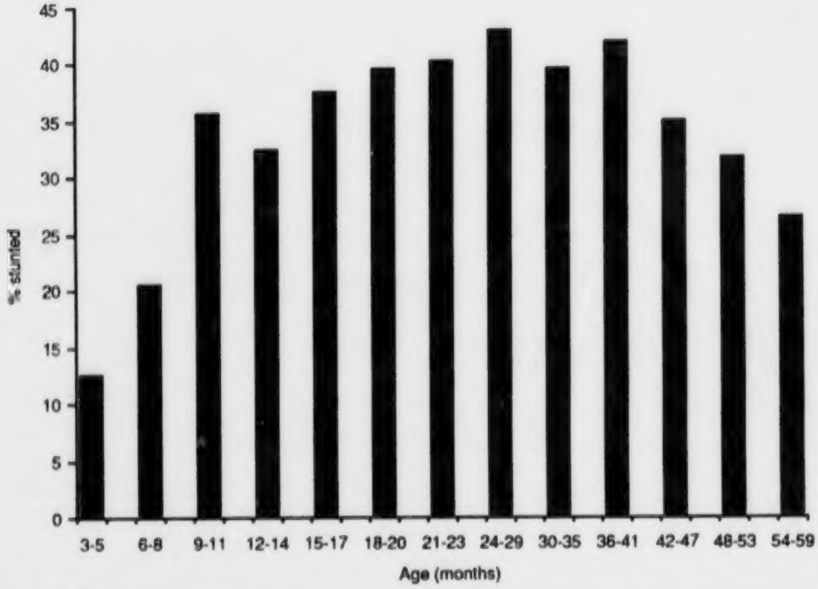

Fig. 2. Prevalence of stunting, in communal areas only (% of children with standard deviation score for height-for-age less than -2).

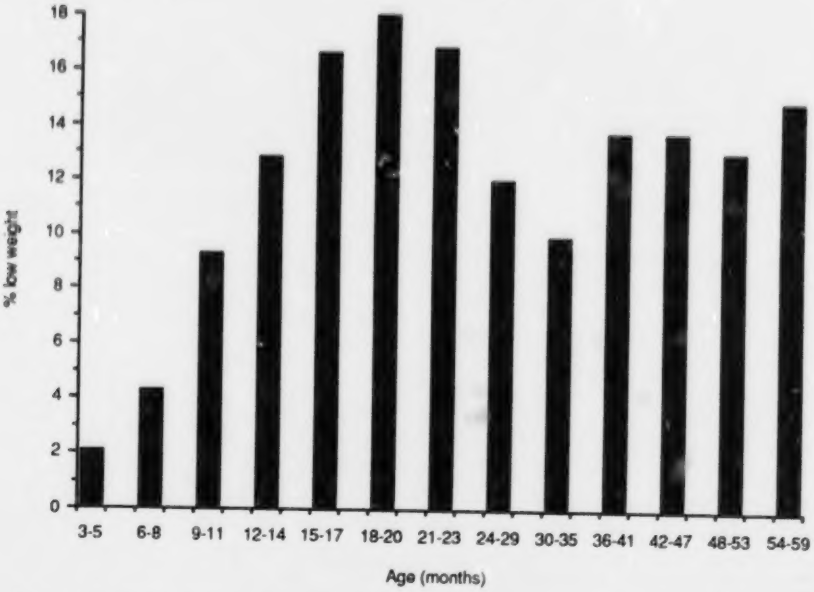

Fig. 3. Prevalence of low weight, in communal areas only (% of children with standard deviation score for weight-for-age less than -2).

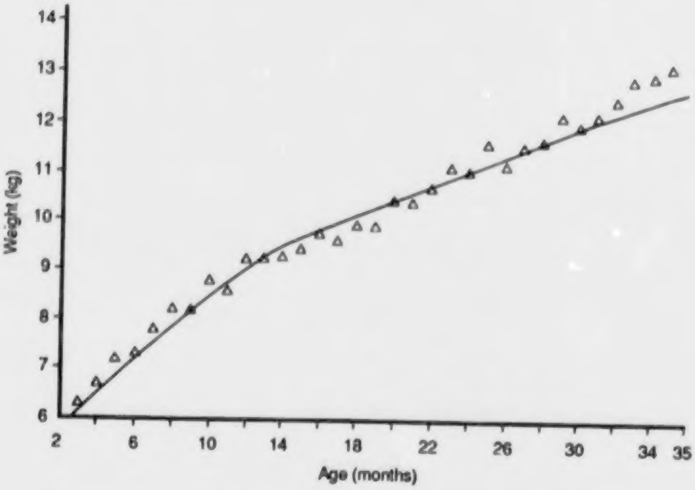

Fig. 4. Mean weight by age, in communal areas only.

expressed that the rate of malnutrition among children under 5 years of age had been lower than it is today. Most children had traditionally been breastfed for at least 24 months. Sour porridge had been widely used as a weaning food; enough would be prepared to last 3 or 4 days, thus saving on fuel and reducing the mother's workload. The roots of herbs would be placed in an earthenware pot and the cooked porridge poured over them; these herbs supposedly effected rapid weight gain. The mixture and the earthenware pot were referred to as "shupa." The use of this soured mixture was not associated with diarrheal episodes.

A flour made from dried thin slices of sweet potatoes was sometimes added to the porridge just before serving. This improved the palatability of the porridge and also increased its energy density. The sweet potatoes were sliced and sun dried soon after harvest. Powder from a sweet-tasting root was also used to sweeten the porridge.

A cereal paste made with water and any locally available ground cereal grains (e.g., maize, sorghum, millet) was sometimes used for porridge: it would be simmered for a while before being placed over the roots of the herbs in the earthenware pot. A portion of this could be served immediately, and the rest throughout the day for 3 or 4 days, as required.

Discussion

These traditional methods of child feeding are no longer in use in Zimbabwe; very few young mothers are even aware of them. The information given, though scanty, could be used as a starting point for research aimed at improving local weaning diets. Research to date indicates, for example, that the incidence of diarrhea is greater when fermented weaning diets are used; this seems to contradict the claims of the interviewed elders. Further research should be carried out to establish whether root powders, in addition to improving the palatability of the fermented porridge, improve the storage capability of the mixture, and whether they reduce the bacterial counts for diarrhea-causing organisms. Laboratory work could determine whether the traditional additives have any nutritional value, and if so, the quantities that are needed to meet a child's physiological needs.

On the basis of the information provided by the elders, more research should be undertaken into traditional weaning practices; in this way, we can work to improve present weaning practices.

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USE OF FERMENTED FOODS IN CHILD FEEDING IN BOTSWANA

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Abstract *Porridges, both fermented and unfermented, are used as weaning foods in Botswana. These porridges are prepared from available cereals (sorghum, millet, and maize), and are particularly valued in times of food shortage. The unfermented porridges are, however, bulky and are low in energy and in other nutrients necessary for the child's growth and development. Fermentation, a method of food processing common in Botswana, has been found to increase the palatability and nutritional value of porridges, to decrease their bulk, and to extend their shelf life. Because malnutrition in Botswana is prevalent during the weaning period, the use of fermented porridges could help to alleviate early weaning problems. To secure baseline information on the use of fermented foods during weaning, a study is needed on weaning foods and on weaning practices in Botswana; such a study may be most revealing in those areas in which the appropriate technology is already in place.*

In Botswana, most rural households eat three meals per day. The morning meal is light, consisting of tea and soft porridge. After a heavy morning's work, the midday meal is eaten; this meal is considered the most important of the day, and a greater variety of items is served than at other times. The evening meal is also light and, in most cases, is similar to the morning meal. This basic pattern changes, however, when food resources are plentiful: if the family has experienced an abundant harvest, more food is cooked and leftovers are common; family members are then able to help themselves throughout the day. Except during periods of food surplus, however, eating between meals is not a well-established Setswana custom.

The Tswana tradition recognizes pregnancy as the period most significant to the infant's later nutritional status. During pregnancy, specific foods are considered necessary: pregnant Tswana women are encouraged to drink as much milk as they wish; they may even move to the family cattle post to be near the source of the milk. Other foods considered beneficial during pregnancy include meat, green vegetables, and porridge.

After delivery, the mother enters confinement, a period of seclusion lasting anywhere from 3 to 6 months. During confinement, the mother and the child are attended by an elderly woman, preferably beyond child-bearing age, who takes care of the baby and prepares and serves the mother's food. (Other members of the family eat from a separate pot.) The mother is fed as much porridge, fresh milk, meat, and other foods as she wishes and is encouraged to take as much fluid as possible. During confinement, she may in fact be the best-fed member of the family: the others often sacrifice portions of their food so that she may receive the largest share. During this period, the maintenance of breast-milk production is of concern both to the caretaker and to the mother.

After the confinement period, the mothers go back to their regular heavy workload - one that leaves them little time to feed either themselves or their families properly. The mother and child enter, therefore, into a pattern of eating that is inadequate, in terms both of the nutritional value of the food and of the frequency of feeding. This situation has serious implications for child growth and health: because breast-milk production decreases with improper feeding and with infrequent sucking, the child's growth begins to falter. [Editor's note: many studies find milk supply is affected only with severe malnutrition.]

According to the results of the 1984 Family Health Survey, children in Botswana are breastfed, on average, for 19 months. Women, especially in rural areas, have been known to breastfeed until another pregnancy occurs or while their supply of breast milk is still adequate. In fact, studies have shown that some women breastfeed up to 4 years. The same survey also showed that although malnutrition is very low in children 0-6 months of age, the levels rise thereafter to 20-30%. Malnutrition is more prevalent after the first 6 months: other foods are then introduced into the diet, and other factors come into play at the household and community level; feeding practices are generally related to economic, social, technological, and biological factors.

Weaning Practices

Traditionally, the timing of the weaning process has been vague. It is determined both by cultural and by socioeconomic factors, including: household food availability, recurrence of pregnancy, infant sickness (especially where the mother's milk is considered a contributing factor), and cultural beliefs and practices, particularly those concerning food consumption and child rearing.

Once it has been decided to wean the child, several methods may be used: the child may be separated from the mother by being sent away to relatives for several months; the child may be forced to stop breastfeeding by the application of unpleasant tastes on the breasts; or the mother may simply refuse to breastfeed. These abrupt steps are usually taken before the child has had sufficient time to accustom himself or herself to other foods. Such abrupt weaning often culminates in emotional upsets, resulting in loss of appetite and in ill health. With improved health education programs, more mothers are beginning to wean their children gradually after 4-6 months of age, and to do so in such a way that they avoid detrimental weaning practices.

Weaning Foods

Except for a small percentage of children of working urban mothers and of the few well-to-do rural mothers, the weaning child in Botswana seldom receives commercially prepared foods. The traditional weaning food in Botswana is fresh milk - cow's milk or goat's milk, depending on availability. During the weaning period, children are taken to the cattle post, where milk is easily available; it is not unusual for a child to be fed on milk and no other supplementary food. In fact, children are encouraged to consume a certain amount of milk before being offered any other food.

Once the milk intake satisfies the mother or the caretaker, the child is gradually introduced to adult foods that are considered suitable for weaning. These are mainly porridges made from locally available staple cereals. The porridges might be prepared with milk, water, or sour milk, depending on the parent's preference for the day. The amount of added protein supplement (milk) varies according to availability. Because children are fed from the family pot, the frequency with which the child is fed depends on the meal schedule of the whole family.

Sorghum has historically been the preferred staple of most Batswana and, because it is more drought resistant than maize, is the cereal most suited to the prevailing climatic conditions. Millet is the staple preferred by the Bakalaka of northern Botswana. Traditionally, Batswana maize porridge ("phaleche") was viewed as a food for periods of drought and was not considered suitable for growing children. Over the years, however, consumer preference has shifted away from sorghum toward maize meal. This is attributed to the fact that maize meal is available commercially - prepackaged, and therefore convenient. Because sorghum meal is not produced commercially, it must be produced within the household and must, therefore, be hand-pounded; hand pounding or stamping is a daily task that takes 1-3 h of the women's time.

To encourage the demand for sorghum meal, the Botswana Agricultural Marketing Board and Rural Industries Innovations Centre has begun to install commercial sorghum mills. The positive response has indicated that there was indeed a demand for a commercially produced sorghum meal. From the government's standpoint, the objective of introducing sorghum processing was to promote food security - to stimulate demand for surplus production of sorghum and, thereby, to increase the national supply of a staple well suited to Botswana's drought-prone climate. If this objective materializes, the availability of commercially produced sorghum could restore this cereal to its former popularity and could help significantly to reduce the workload of the women.

In almost every part of Botswana, porridge is widely used for weaning. Cultural factors play a role, however, in determining the choice of porridge type: fermented porridge ("ting") is preferred by the Tswana societies in southeastern Botswana, by the Bakgatla, by the Balete, and by the Batlokwa; those tribes living in the west and north of the country generally prefer unfermented porridges. Although the use of fermented porridge has, over the years, spread to other tribes, it is only in the southeast that it is given to weaning children. This may be because adults experiencing "heartburn" after eating fermented porridge believe that their children will have the same problem.

"Ting" is prepared in a container (traditionally, clay pots; today, any type of container). The grain is mixed with warm water to form a thick paste; it is then put in a warm area. To hasten the new fermentation, leftovers from previous fermentations may be used to start fresh fermentations. The mixture is then left overnight, after which it is ready for use.

Conclusions

Baseline information is needed on the use and preparation of various foods for weaning and on traditional weaning practices. With this information, it should be possible to design appropriate interventions to reduce malnutrition in weaning-age children.

WEANING PRACTICES IN SWAZILAND AND SOCIAL MARKETING TO EFFECT CHANGE

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Abstract *A project currently underway in Swaziland has as its objective the designing of strategies to improve the nutritional and health status of young children. This project is being undertaken in four stages: assessment, strategy formulation and design, implementation, and monitoring and evaluation. Because the work is at an early stage, only one of the assessment activities - the focus group survey - is presented here. Such a survey is exploratory in nature and uses informal, ad hoc discussion with small groups of potential program beneficiaries. The focus group discussions in this survey dealt with the following issues: health status of the children (as perceived by the parents), health indicators, child illnesses, parental aspirations, and child feeding and rearing, including access to health-care information. Results from this survey will be used for further, in-depth study and planning in the subsequent project activities; these activities will include the use of "social marketing" techniques and mass communication and training.*

A project currently underway in Swaziland aims at improving child-feeding practices through a program of mass communication and training. This project is sponsored by the United Nations Children's Fund (UNICEF) and the United States Agency for International Development (USAID). The National Nutrition Council (NNC) is responsible for the implementation of the project and for the coordination of the various ministries involved. Government personnel have been seconded to the project on a full-time basis. The project arises out of the findings of the 1983 National Nutrition Status Survey - the most comprehensive of several nutrition-related studies that have been carried out over the last 5 years in Swaziland. This survey documents problems concerning the nutrition of young children and indicates those factors associated with chronic undernutrition, that emerge consistently from study to study. These factors include the following:

- The highest level of stunting occurs among rural children in the age group 18-23 months (42%);

- The period of exclusive breastfeeding is extremely short or nonexistent; nonhuman milk is introduced in the first few weeks of life;

- The introduction of semisolid food occurs too early; although studies indicate that the first food is usually soft maize porridge, little information is available on how it is prepared and how much is given;

- Young children are fed a relatively restricted diet, in terms of the number of foods provided; no detailed information is available, however, specific to children under 2 years of age;

- In general, the children eat together from a common dish; this makes it difficult to gauge the quantity of food consumed by a single child;

- Little information is available as to the type of snacks given to children under 2 years of age;

- It is likely that practices vary less according to agroecological zone than socioeconomic environment; and

- Child-feeding practices require particular attention in families in which parents have little or no formal schooling and in which incomes are low.

Project Description

The project will use communications as a means of attaining its objectives. Attempts in many countries to improve nutrition through education and communication have failed because of insufficient attention, at the program-design stage, to the practicability of messages and to the identification of appropriate communications groups. This project will attempt to avoid these pitfalls by paying careful attention to the design of the messages and to the pretesting phases. As a result, the actual dissemination of messages will not take place until relatively late in the project.

The project will use "social marketing" techniques to identify specific nutrition problems, target groups, and desired changes in behaviour. It is necessary that researchers obtain answers to the following fundamental questions: why mothers feed their children as they do; what resources these mothers would be prepared to mobilize for the improvement of young child feeding; and what would be the most effective way of promoting and encouraging change.

The project is being undertaken in four stages, each stage building on the previous one:

- Phase I - Assessment: literature review, focus group survey, and household interviews with intervention trials;

- Phase II - Strategy Formulation and Design: strategy formulation, development of prototype messages and materials, message and material pretest, message and material revision and production, training plans, baseline survey, and establishment of monitoring and evaluation framework;

- Phase III - Implementation: communications skills and program orientation workshops, a mass-media program, and tracking and monitoring studies; and

- Phase IV - Monitoring and Evaluation: baseline survey repeated and other relevant data analyzed.

The ultimate objective is the designing of project strategies with the potential for improving the nutritional and health status of young children. As regards the current status of the project, the focus group survey has been completed and the in-depth household survey is being designed.

Phase I - Assessment

The objective of the assessment phase is the achievement of a comprehensive understanding of current infant and young child feeding practices - of the rationale behind them, and of the conditions that may influence them. During this assessment phase, three research techniques (literature review, focus group survey, and in-depth household interviews) will be used to gather information.

Focus Group Survey

A focus group session is an informal, ad hoc discussion with a small group of people (about eight) who are potential program beneficiaries. Such a setting makes it possible to learn directly from future "clients" the reasons for their choice of certain products or for their upholding of certain practices. It is essential that each group be as homogeneous as possible: the more characteristics members have in common, the less likelihood there is that interacting demographic and socioeconomic variables bias the discussion. It should be emphasized that a focus group discussion is exploratory in nature and should therefore be as informal as possible.

Because focus group samples are small, the data generated by this type of study cannot be used to quantify a problem or to make projections that would generalize the findings to other populations. The data that has been generated in these discussions will assist in the following ways:

- It will provide background information on infant and child feeding, on child rearing, and on children in general;

- It will help to generate ideas or hypotheses for further study during the in-depth household interviews; and

- It will assist in the segmentation of target groups and thus in the designing of messages tailored to these groups.

In the present study, five different "population groups" were interviewed. The selection of these groups was based on the findings of the 1983 National Nutrition Status Survey; this survey showed that stunting was associated with a low level of parental education, and that the prevalence of stunting was highest among children in the weaning age group. The five population groups are identified as follows:

- "General mothers" - mothers who have less than Form 3 education (without Junior High School certificate) and who are the primary caretakers of children less than 24 months of age; this group includes female caretakers who are of the same generation as the biological mothers;

- "Young mothers" - mothers who have a Form 3 education or less (about 3 years or less of Junior High School) and who have only one child under 24 months of age;

- "Working mothers" - mothers who have a Form 3 education or less and who work outside the home for more than 6 h/day, leaving behind children less than 24 months of age;

- "Fathers" - fathers who have Form 3 education or less and who are caring for children under 60 months of age; and

- "Grandmothers" - grandmothers (or female caretakers who are one generation older than the biological mothers) who are the primary caretakers of children less than 24 months of age.

The 1983 National Nutrition Status Survey showed that stunting does not vary with agroecological zone or with administrative region. There is, however, a general hypothesis that child-feeding practices vary with the degree of urbanization; the field sites were selected on this basis: rural, remote (Hhelehhele, Hhohho); rural, accessible (Mbekelweni); periurban, low income, (Kakhoza); periurban, middle income (Mobeni, Matsapha); and company town (Ubombo).

To understand the participants' ideas on child feeding and rearing, the following topics were discussed: perceived health status of the survey child; health indicators (for children only); childhood illness; generational change in attitudes; aspirations (of parents for their young children and for themselves); and access to information. A total of 20 focus group sessions were held; these sessions were taped and transposed into verbatim transcripts.

The process of analysis comprised the following three steps: summaries of each focus group by topic; descriptions of each topic by population group and by area; and description of each topic, with all groups in combination, i.e., a national profile. The fieldwork took about 4 months, as did the period of analysis.

Summary of Results

The summary of results presented in this paper will give only a glimpse into the findings; this may, however, suffice to give the reader an appreciation of the type of information that can be obtained from focus group discussions.

Perceived Health Status

Asked if they considered their children to be healthy, most parents answered positively. According to these parents, a child was in good health when the following circumstances obtained: when the child was well fed; when he or she had been immunized, both by traditional and by modern methods; when there was evident weight gain; and when the child was at ease, happy, and lively. Children were considered unhealthy when they suffered from diarrhea and vomitting, from intestinal worms, or from colds.

Asked if their children were growing, most parents again answered positively; in this instance, their evaluation was based on the children's ability to sit, to talk, to stand, etc., and on the fact that these children were pleasant to look at and were always happy. The grandmothers, however, in saying that their grandchildren were not growing very well, suggested that these children were not pleasant to look at and were not well fed.

Health Indicators

To facilitate a discussion on indicators to health, two pictures were used. One showed a healthy, well-nourished baby; the other, an undernourished baby. The healthy baby was described by the participants in terms suggestive of happiness, health, strength, and activity. The baby was said to have a loving mother. The home of the healthy baby was described as a home full of joy, of life, and of caring; it was also suggested by several groups that cleanliness was an important factor.

The undernourished baby was said not to be well fed: the opinion was that it had not received food from all three food groups. The participants also said that the stomach of the unhealthy baby was overly large and that he was suffering from diarrhea. A look of unhappiness was also mentioned as evidence that the child was not healthy. His mother was described by the other mothers as irresponsible, "unrestful," untidy, and lazy. The fathers described the mother as someone who drinks a great deal even when pregnant and who feeds the child on porridge only. The home of the undernourished child was described as dirty and poor. Some said that the home might be rich, but the parents careless: for the child to become undernourished, it was said, the parents had not practiced family planning; the woman had consequently become pregnant again too soon, and there was therefore no enthusiasm in the home for this child.

Child Rearing

To ensure that a child stays healthy, several practices were recommended: feeding the child well with foods that enrich the blood; giving a milk formula or cow's milk to the child; and maintaining general cleanliness. Also mentioned was breastfeeding, and taking a sick child to the clinic or to the traditional healer. The health habits of the mother were also of some concern. Most mothers said that it was important to attend antenatal clinics. Fathers and grandmothers said that the mother-to-be should be well fed and should abstain from harmful habits such as drinking alcohol.

Most groups described a number of rituals that a child should undergo. It was recommended that at birth, the child be given boiled water with a little sugar and salt, or boiled water with a starch gruel. Traditional rituals and BCG immunization were said to be important for the young infant.

When the child is a little older, it is considered important to introduce it to Swazi culture by letting it eat from the same plate as the other children. It is believed that this practice stimulates the appetitie and saves on relish. Because the older children secure most of the food, however, and because the children fight, some participants were against this usage of communal plates.

Child Feeding

Most mothers give boiled water with sugar and salt immediately after birth. This practice was said to clear the stomach and to satisfy hunger until the breast milk begins to flow. Many of the mothers said that they did it for no particular reason, except that it is a practice that has been handed down by previous generations. The water feeds are sometimes continued for 2-3 months. Those who had given birth at a hospital said that they had been advised to breastfeed immediately (a practice that is being slowly adopted in hospitals). A few mothers said that they still give the traditional first feed (a starchy gruel) to test the digestive system and to introduce the infant to the home.

Most mothers feel that it is necessary to complement breast milk from an early age. Some begin as early as the 1st week of life, whereas others wait for 1-2 months. They time the initiation of complementation according to the tendency of the baby to cry even after breastfeeding; another gauge is the point at which the baby begins to look at the mother when eating. Some mothers are advised by their own mothers or by the clinic as to this timing. The working mothers said that they must begin complementation as soon as they return to work - from 2 weeks to 2 months, depending on the length of maternity leave allowed.

The most popular supplements are formulas and powdered milks. The particular choice is usually made by trial and error: one brand is tried, and if the baby doesn't like it, another brand is substituted. Moreover, infant formulas and powdered milks are used interchangeably. It is common for the mothers to be advised by their clinic as to a choice of supplement, especially if they have had problems in breastfeeding. Some mothers said that they were advised by relatives or neighbours; some said that the father of the child brought the milk. Young mothers confessed that although they did have enough breast milk, it was exciting to feed the baby with a bottle.

When the infant is 2-4 months old, he or she is often started on soft maize porridge. The porridge is made out of finely groung maize; milk, sugar, and a raw egg are usually added before feeding. The porridge is given in a bottle or by cup and spoon. Because a highly refined maize meal is used, the child's porridge is always cooked separately from the family porridge. If the mother is present, she cooks and feeds the baby herself; otherwise it is the grandmother or a caretaker who gives the feed. From 3 to 6 months, the infant is started on family foods, and when it is big enough to crawl or to express its will, it joins the other children at the common plate. Because fermented sour porridge is believed to cause heartburn and vomiting, it was said to be unsuitable for young children; for the same reason, sour milk is rarely given to infants. Asked what foods are especially good for children, the groups listed milk, soft porridge, fruits, and "body-building foods." It was said to be appropriate to terminate breastfeeding when the child is able to follow simple instructions, or to ask for the breast.

A major problem in child feeding is lack of appetite. If a child hasn't a good appetite, it is given "appetite medicine" and an enema, or is force fed. The working mothers in particular said that they have problems with child minders, who do not feed the children well. Many grandmothers said that the children are simply "dumped" on them, with no financial support from the parents, especially from the fathers.

Child Illnesses

The childhood illnesses most commonly recognized by all the groups were diarrhea and vomiting. (Diarrhea is treated with a home-prepared salt/sugar solution; the enema was also mentioned as an important treatment.) Other illnesses that were recognized as very common were measles, coughing, rashes, and sore throat. All parents said that they take their sick children to hospitals and to clinics. Most of the population groups said that although they use both modern and traditional medicine, they do know of people who use traditional medicine only. Most mothers do not change the diet when their children are sick; although many fathers expressed their approval of such a change of diet, they said that it was the mother's responsibility. Suggestions for change in diet included elimination of the food that caused the illness; continuation of breastfeeding; provision of foods liked by the child; and provision of light food.

Aspirations

The wish most often expressed among the parents was that their children be healthy and live to adulthood. Education and economic independence were also high priorities, as was an enhancement of the children's social conduct. Most of the parents stated that they would like their children to live in rural areas; there is a belief that these areas offer better chances of economic independence and closer family ties; there is also the feeling that the children will ultimately develop these areas. The only opposition to this view was expressed by fathers from the periurban area, who preferred their children to live in the towns.

With the exception of the working mothers, most parents expressed the wish to see their children follow Swazi tradition and culture. The working mothers considered it more realistic to expect their children to mix Swazi and modern culture. Again, with the exception of the working mothers, most mothers wished to be economically independent: they did not like having to depend either on their parents or on their partners. By the same token, fathers and working mothers aspired to self-reliance: they wished not to have to depend on outside employment for a source of income. The young mothers specifically expressed a wish to be married. Because the fathers wished to buried at home rather than in a cemetery, their desire for a home was made clear.

The participants were also asked how they would spend an unexpected, large sum of money. The female groups expressed a strong desire for income-generating activities. The fathers were not specific; they indicated that they would take the money home and make the decision with their spouses.

Generating Change

The participants were asked if their views on child feeding and rearing differ from those of their parents. The young mothers said that they take advice from their parents and therefore share their views. Most participants, however, said that their opinions on these issues differ considerably from those of their parents.

This was expressed most emphatically by the general mothers: these mothers noted that, whereas the older generation had fed infants on cow's milk, starch gruel, sour milk, and other household foods, the younger generation gives formulas, tinned milk, and instant baby foods to its infants. Other changes were mentioned by participants: today, parents rush to the hospitals when their children are sick, whereas the previous generation resorted first to traditional healers; there are new diseases, such as whooping cough, tetanus, and polio; and as the fathers pointed out, the previous generation had been self-reliant and economically independent, with a different way of life and a lower cost of living.

Information Access on Child Feeding and Rearing

The most common source of information seems to be the clinic or hospital. The elders constitute another important source, especially, where financial advice is concerned, the female elders. Home economists were mentioned by all the groups except young and working mothers. Other sources are neighbours and traditional healers. Only fathers mentioned the radio as a source of information. Interestingly, all groups except working mothers and grandmothers agreed that they listen to the radio. Participants said that although they regard messages from both the clinic and the radio as reliable, some of the advice given is impractical: an example given was the boiling of drinking water.

Although most female participants were aware of organizations (e.g., women's groups, Red Cross, Sebenta) existing in their areas, only the grandmothers claimed to be members. Most fathers said that they were members of existing organizations in their areas. When asked if they take their children to clinics, all mothers except the working mothers said that they take the children for weighing and for immunization. Most mothers said, however, that they could not interpret the health card. The few who claimed to be able to do so were able to read only the dates for the next immunization. The fathers said that although they did not take their children to clinics, they encouraged their wives to do so.

The data from these sessions give an overall impression of the participants' ideas. The more detailed material, not presented in this paper, gives the findings specific to particular population groups or areas. This detailed material, containing selected verbatim transcripts, will be used in the project to generate ideas and hypotheses; these can be developed, first during the imminent in-depth household survey, and later, in the program activities.

A STRATEGY TO IMPROVE WEANING PRACTICES IN MOZAMBIQUE

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Abstract *Like most Third World countries, Mozambique suffers increasing levels of weaning age malnutrition. The "weaning age," as it is here defined, begins with the provision of foods supplementary to breast milk; the period is considered to end with the cessation of breastfeeding, when the child is fed entirely on the family diet. The data available indicate that, on the whole, chronic malnutrition occurs during intrauterine life and during the first part of the weaning period (from 3 to 12 months of age). The costs of malnutrition to the country are heavy, not only in loss of life, but also in terms of increased health and education expenditures; other effects are loss of productivity, retardation in psychosocial development, and increased marginalization from society. The cost of national strategies to control the high incidence of low birth weight and of weaning age malnutrition is notably lower than the social cost of malnutrition. The objective of this paper is to suggest a basis for a weaning food strategy that could be implemented in Mozambique.*

Mozambique has an estimated population of 14.5 million and is a predominantly agrarian society. Table 1 presents a breakdown of population characteristics at the national level. Mozambique has suffered a long history of underdevelopment: levels of investment have been low, both economically and in terms of human resources; dependence has been great on markets outside the country, particularly on those of Portugal and South Africa; and there has been a considerable dislocation of labour. Part of this dislocation took the form of migration to the South African mining and farming sectors, and of forced internal labour on the plantations and on construction projects. The total number of Mozambicans working outside the country has often reached half a million. Mozambique thus developed as a service economy for the colonial power, supplying cheap labour and low-cost routes to the sea.

The way in which independence occurred - by means of a protracted war of liberation - contributed further to a weakening of the social reconstruction. A mass exodus of the settler population deprived the new state of much of its technical, administrative, and commercial skill. South Africa reduced its use of Mozambican port facilities and its recruitment of mine workers, thus depriving the country of two

Table 1. Mozambican national profile, 1987.

Population	14516000
Displaced	1569000
Affected by war and drought	2973000
Displaced and affected	4542000
Urban to be supplied	1958000
Total population for food supply	6500000
Infant mortality rate	200 per thousand
GNP per capita	USD 97.5
Child malnutrition	57%
Low birth weight	20.0%
Population growth	2.6% per year
Adult literacy	27.8%
Food supply needed	930000 t
Food expected to arrive	457000 t

Source: UNICEF 1987a.

major sources of foreign exchange. Natural disasters, especially drought, further increased the burdens of the country. Finally, the effects of banditry (carried out without a political program) became increasingly severe in the 1980s.

Mozambique faces its 6th successive year of negative economic growth, resulting from destabilization, natural disasters, and economic recession. In 1987, the Economic Recovery Programme (PRE) and the National Emergency Programme (NEP) were initiated. Despite the existence of these programs, Mozambican families remain extremely vulnerable to food shortages and to scarcities of basic goods; they also suffer lack of income and of access to social services. Most horrifyingly, there is the threat of death, kidnap, rape, mutilation, and displacement because of the banditry that is affecting all the provinces. Since 1987, this banditry has been directed increasingly at the civilian population; in July-August 1987, a number of barbaric massacres took place in the south of the country, the first of which, at Homoine, resulted in the deaths of more than 400 people, of whom a high proportion were women and children (UNICEF 1987b).

Legislation on Mothers and Children

During the period between 1975 and 1980, the government introduced a series of laws to protect women and small children. Provision was made for a 2-month maternity leave and for the right to free time at work to breastfeed young babies. Part of a new family law gives women protection in the areas of divorce, desertion, and child custody. These laws bring radical change from those formerly based on Portuguese law and tribal custom: the courts, for example, are expected to decide child custody on the basis of the child's interest, rather than on traditional "ownership rights."

According to the Mozambican Women's Organization (OMM), however, some tribal traditions continue that may have positive aspects. OMM considers that so-called "initiation rites" may help to teach sexual hygiene. Similarly, they suggest that "lobolo" is not simply the buying of a bride, but is an agreement, made between the two families, that can provide increased stability to the new marriage. Polygamy, they say, can help to reduce the work load of women: in areas, for example, where water is several hours' walk away, shared water collecting could mean one or two fewer working hours per day.

The Health System

Mozambique has been in the forefront of health internationally, often steps ahead of many Third World countries and of the World Health Organization (WHO). Some time ago, health care was nationalized and socialized; in spite of war, drought, and economic pressures, the coverage of health services has been expanded, especially in the rural areas, giving millions of people access to at least rudimentary health care. Emphasis on primary health care was made national policy in 1977, 1 year before the WHO/United Nations Children's Fund (UNICEF) meeting at Alma Ata.

Because of the armed bandits, however, the coverage provided by these health services has been severely reduced. In the period from 1982 to 1986, 484 health facilities - about one-third of those available - were destroyed. Approximately 2 million people who had been covered by these services in 1981 can no longer receive them.

Food Production and Availability

The June 1987 Report of the Department of Food Security, Ministry of Commerce, described a very serious situation (see Table 1). The report was based on an estimate of 1.6 million displaced people, and of a further 3 million people affected by food shortages in rural areas alone. Taking into consideration the fact that the urban areas had also to be supplied, the report gave as a projected estimate an import need of 930,000 t of basic cereals for the period from May 1987 to April 1988; it was judged that this level of import would supply 6.5 million people. A year earlier, in July 1986, the import needs of the country had been 580,000 t to supply 4.9 million people.

The U.S. Department of Agriculture's estimate of cereal production was only 493,000 t in 1987, as compared with 605,000 t in 1982, when the cycle of drought and destabilization began. Official figures have fallen even more dramatically, however, from 132,000 t in 1982 to some 40,000 t in 1986, with a slight improvement expected for 1987.

In summary, 45% of the population depends on relief supplies of food totalling 930,000 t. In 1987, 457,000 t of food aid is expected to arrive, leaving 51% of the estimated needs uncovered. In addition, the assumption has been that the 55% of the population not included in these supply systems is in fact "self-provisioning" with respect to basic nutritional needs; this assumption has been admitted to be questionable (UNICEF 1987c). The main foods provided through the New Food Supply Network (Nova Rede de Abastecimento) are corn, oil, sugar, and salt; occasionally, dry skim milk is also available. In many areas of the country, the limited food supply available at the local level is further reduced to corn, sorghum, cassava, and green leaves. Small quantities of other foods are added to these staples: in Inhambane province, peanuts and beans are available in small quantities; in the Zambezia province, coconuts and a little rice are available; in Manica, there are limited supplies of sugarcane and of beans. Small fish are available in areas close to rivers and to the Indian Ocean coast; other animal protein sources are unavailable in most parts of the country.

Historic trends in the country suggest that sorghum, beans, and rice (main staples 30 years ago) were gradually replaced by corn. Today, in many areas, corn is being replaced by cassava when the latter is available. The implication is not only that total energy intake is decreasing, but also that protein intake is being lowered to dangerous levels, particularly in populations affected by war and drought.

Prevalence of Malnutrition

There are reports of widespread kwashiorkor and marasmus in Mozambique, particularly in the displaced populations. Data from several surveys also suggest that the prevalence of both acute and chronic malnutrition increased during 1987. Available estimates indicate that the prevalence of malnutrition is 57%, which means that about 1.4 million children under 5 years of age are currently malnourished (UNICEF 1987b).

The data in Fig. 1 (JNSP 1987) present the incidence of growth-faltering for 0-5 and 6-11 months of age; these levels are compared

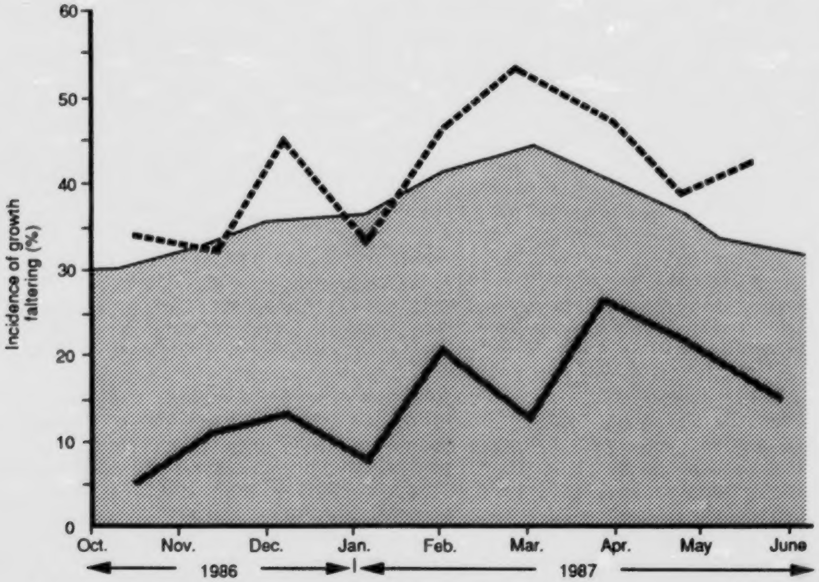

Fig. 1. Prevalence of growth-faltering in Mozambique, Maputo green zones (poor, periurban) at 0-5 (solid line) and 6-11 (dashed line) months of age. The shaded area represents the level of growth-faltering for the entire group of children from 0 to 59 months of age.

with levels observed for the entire group of children from 0 to 59 months of age. In this analysis, growth-faltering is defined as a gaining of less than 50% of the standard increment (National Center for Health Statistics, NCHS) over a given period, usually of 1 month. Two facts become clear from these figures: the first is that because of the prevalence of exclusive breastfeeding in the group 0-5 months of age, the incidence of growth-faltering is significantly lower here than in the total group; the second finding is that growth-faltering is significantly higher in the group 6-11 months of age, probably because of deficient food intake and a higher incidence of common infections.

Other reported data clearly indicate that the prevalence of growth-faltering increases steadily from 3 to 12 months of age. The weaning age, as it is here defined, begins with the provision of foods supplementary to breast milk and ends with the cessation of breastfeeding, when the child is fed entirely on the family diet; in Mozambique, as in many other poor countries, the levels of malnutrition rise notably during this period.

Breastfeeding

Mozambique was one of the first countries to ban the import of breast milk substitutes and bottles produced by the multinational companies and to distribute a domestic brand of milk with labels emphasizing the superiority of breast milk.

Tables 2 and 3 present the data available on breastfeeding. Two conclusions can be drawn from this data: firstly, the prevalence of breastfeeding per se is very high; secondly, as was expected, the prevalence of exclusive breastfeeding is not as high. These figures indicate that by 6 months of age, 80% of children are eating significant quantities of foods supplementary to breast milk, and that at 30 months of age, 98% of children have ended their weaning period

Table 2. Surveys on the prevalence of breastfeeding by age in Mozambique.

Age (months)	National 1984-85 (1219) (%)	Beira 1985 (242) (%)	Changara 1985 (68) (%)	Quelimane 1985 (200) (%)	Inhamisa 1987 (250) (%)	Median (4 surveys) (1985-87) (%)
0	95.8	100.0	100.0	100.0	100.0	100.0
3	-	97.0	99.0	98.0	100.0	98.5
6	93.2	95.0	97.0	94.0	100.0	96.0
9	-	93.0	96.0	86.0	99.0	94.5
12	75.7	92.0	94.0	82.0	98.0	93.0
18	52.3	71.0	74.0	42.0	79.0	72.5
24	-	48.0	38.0	16.0	45.0	41.5
30	-	2.0	6.0	0.0	2.0	2.0

Note: Percentages are estimated from cumulative rates of continuity per child breastfed at birth. Values in parentheses represent sample sizes.

Table 3. Prevalence of exclusive breastfeeding by age in Mozambique, 1985-87.

Age (months)	Beira 1985 (242) (%)	Changara 1985 (68) (%)	Inhamissa 1987 (250) (%)	Median (%)
0	100	100	100	100
3	90	49	100	90
6	20	14	76	20
9	4	3	36	4
2	3	2	16	3
18	2	1	4	2
24	1	0	1	1

Source: UNICEF (1987c).
Note: Values in parentheses are sample sizes.

Table 4. Meal composition during weaning in Mozambique, Beira Green Zones Survey, May 1985 (poor, periurban).

Food[a]	Present	Absent	Total
Oil	26 (18.1)	118 (81.9)	144
Sugar	95 (58.3)	68 (41.7)	163
Beans	28 (19.2)	118 (80.8)	146
Fruit	12 (8.6)	128 (91.4)	140
Green leaves	46 (30.3)	106 (69.7)	152

Note: Values in parentheses are percentages of the total.
Source: UNICEF (1987c).
[a] Corn was present in all meals.

and are partaking of the family diet. The weaning period in these populations can therefore be said to last from 3 to 30 months of age. A sizeable proportion (70%) of the population introduces weaning foods within the period critical to such feeding, i.e., 3-6 months of age.

Weaning Practices

Weaning practices vary considerably from urban to periurban and rural areas. In rural and periurban areas, women participate heavily in the physical tasks of agriculture. It is usual to find them overloaded with agricultural and home-related work. Babies are usually weaned with a very bland, fermented or nonfermented corn flour porridge (in Portuguese, called "papa" or "paninha"). Estimates of its nutrient composition suggest a low energy and protein content (397 kcal and 6.7 g of protein per 100 g). Conditions of preparation also indicate a high probability of contamination.

The UNICEF (1987c) data base indicates that 55% of the weaning babies receive one or two meals per day; 38% receive three meals; and only 7% receive four to six meals per day - the recommended daily frequency of feeding for this age group. Table 4 shows that corn is used in most meals, and sugar in more than half the meals; oil, fruit, and beans, however, appeared in less than one-fifth of the meals surveyed. This picture, with small variations, seems to be the common dietary pattern for weaning children throughout Mozambique, both in the rural and in the periurban poor populations.

Large segments of rural and periurban populations have only one or two mealtimes per day. On these occasions, everybody shares the family pot, usually containing corn flour, water, and some sugar. The adults receive the larger portion of the food. The baby of weaning age eats a small amount of this meal; during the day, he or she will also be breastfed on demand.

Use of Fermented Foods

Table 5 presents, by province, the types of fermented foods currently in use. Corn and sorghum are the ones most commonly found in Mozambique. No information is available either on the number of people using this food or on the quantities of food consumed. It is estimated that, on average, fermented foods account for one-third to one-half of a child's daily energy intake, the rest being provided by breast milk. Because of low frequency of intake, however, the total energy and protein intake is estimated at only 70-90% of that which is recommended. In urban populations and in those rural populations displaced by war, a decreasing trend can be observed in the consumption of fermented food.

The data from Table 6 indicate that, from a sample of 64 mothers interviewed in Maputo City, one-third prepared fermented foods daily and one-third only occasionally. Interestingly, one-sixth had never prepared this type of food, whereas another sixth of the sample had discontinued the practice. The mothers who had never prepared fermented food either had not known how to do so or had had other foods to give to their babies. The mothers who had discontinued the practice had done so because of the "influence of the city" and a lack of corn.

Group discussions conducted with members of OMM revealed that fermented foods were becoming less popular with the new generation of Mozambican women. It was reported that because these women must work outside the home to supplement the family income, they simply have less time for cooking.

In the sample from Maputo City, two reasons were given for the continued use of fermented foods: firstly, the women had been taught the practice by their mothers, their grandmothers, or their neighbours; secondly, the practice was recommended by the hospital that they attended regularly. This was the Jose Macamo Hospital, in Maputo City. (It might be noted here that the hospital cook usually uses fermented foods; he learned the traditional techniques at home.) In general, the mothers said that fermented foods "improve the appetite," "prevent or alleviate diarrheal symptoms," and "make children stronger."

Table 6 also indicates that most mothers who use fermented foods

Table 5. Fermented weaning foods in Mozambique, by province and by ethnic group.

Province	Major ethnic group	Fermented food	Traditional name
Niassa	Yao - Makua - Lomwe	Sorghum	Uputu
		Maize	Mahewu, Uputu, Shima, Shicucumuca, Massa
Cabo Delgado	Makua - Lomwe - Maconde	Sorghum	Uputu
		Maize	Mahewu, Uputu, Shima, Shicucumuca, Massa
		Millet	Shima, Massa, Mahewu, Uputu, Shicucumuca
Manica	Makua - Lomwe	Sorghum	Uputu
		Milk	Masse
Zambezia	Makua - Lomwe	Sorghum	Uputu
		Maize	Mahewu, Uputu, Shima, Shicucumuca, Massa
		Rice	NA
Tete	Maravi - Xona - Karanga	Maize	Mahewu, Uputu, Shima, Shicucumuca, Massa
		Sorghum	Uputu
		Millet	Shima, Massa, Mahewu, Uputu, Shicucumuca
Sofala	Xona - Karanga	Sorghum	Uputu
		Maize	Uswa, Uputu
		Rice	NA
		Millet	Uputu, Uswa
Manica	Xona - Karanga	Maize	Uswa, Uputu
		Sorghum	Uputu
		Millet	Uputu, Uswa
Inhambane	Tsonga - Chopi	Maize	Uswa, Mahewu, Shicucumuca, Uputu
		Sorghum	Uputu
		Millet	Mahewu, Uputu, Uswa, Shicucumuca
		Milk	Masse
Gaza	Tsonga	Maize	Uswa, Mahewu, Shicucumuca, Uputu
		Sorghum	Uputu
		Millet	Mahewu, Uputu, Uswa, Shicucumuca
		Rice	NA
		Milk	Masse
Maputo	Tsonga - Nguni	Maize	Uswa, Mahewu, Uputu, Shicucumuca
		Rice	NA

Note: Fermented or nonfermented porridge is called "Nklathu." In Niassa, "Ugadi" is the name given to any fermented or nonfermented porridge made of maize, sorghum, or millet. NA = not available.

prepare them with corn - either the grain or the flour. Only 5% of this sample reported the use of cereals other than corn.

Table 7 presents the results of chemical and microbiological analyses performed on a sample of fermented porridges. When a porridge is fermented, there is an increase in the proportion of "reducing" sugars, from 18.3 to 45.5%, and a decrease in the proportion of starch, from 70.8 to 43.3%. These changes indicate that, in fermented corn, about 40% of the starch is transformed into smaller molecules with no detectable loss in energy or in protein content. The changes would also explain the decreased viscosity of the fermented porridges.

The data from Table 7 also show that, in spite of at least 24 h storage at room temperature, contamination with E. coli was undetectable in fermented porridges. This may explain in part the repeated reports from mothers in Maputo City and in the provinces, suggesting that fermented porridge helps to prevent diarrhea and to decrease diarrheal symptoms.

Traditional Weaning Foods

Maize and Millet

The recipe names for maize and millet include the following: "massa" (a general name for porridge, whether fermented or not), "uswa" (in southern Mozambique and the central provinces), and "shima" or "massa" (in the north). To prepare fermented maize, the grain is pounded, cleaned, and washed; it is then placed in a mud pot. Lukewarm water is added, and the mixture is left for about 24 h. Some women drain the excess water, dry the maize, and pound it again to produce "mili mili." This is put into a separator that sorts the

Table 6. Habit of preparing fermented weaning food, Maputo City, 1987.

	Number of cases	%
Prepared fermented food		
Daily	22	34.4
Occasionally	23	35.9
Not (interrupted)	9	14.1
Not (never had)	10	15.6
Total	64	100.0
Type of corn product used		
Grain	35	34.3
Flour	33	32.4
Grain and flour	29	28.4
Other cereals	5	4.9
Total	102	100.0

Source: School of Biology, Eduardo Mondlane University, Maputo, Mozambique.

Table 7. **Analysis of fermented and unfermented porridges made with corn.**

	Fermented (%)	**Unfermented (%)**
Chemical analysis		
Humidity	83.7	88.0
Protein	7.0	6.7
Fat	2.4	2.5
Fibre	1.6	1.6
Starch	43.3	70.8
Reducing sugars	45.5	18.3
Ash	0.3	0.4
Energy (kcal)	398.9	397.1
Microbiological analysis		
Contamination by mesophile bacteria (> 1 million/g)	54.5	25.0
Coliform bacteria (> 100/g)	9.1	16.6
Yeast (> 10,000/g)	10.0	33.3
E. coli (> 10/g)	0	0

Source: School of Biology, Eduardo Mondlane University, Maputo, Mozambique.

large from the small grains before cooking. "Mili mili" that is made in the factory is put in a pot full of warm water and fermented for 24 h, after which it is cooked. To avoid making the porridge too sour, it is not fermented for more than 48 h.

Sorghum and Cassava

Sorghum is grown in the north of the country, where it is popular as a fermented food. In most parts of Mozambique, however, it has not traditionally been used as a weaning food. The recipe names for cassava include the following: "shima" (in northern Mozambique), "rali," "maginha," "ghinha," and "mubabane" (in the south), and "karakata" (in Nampula). Most families in Mozambique do not eat fermented cassava. To prepare cassava, the root is scraped and cooked in water, cut into medium-sized slices, and put in the sun until dry (but not so long that it becomes rotten). This dried cassava is then ground and cooked to make porridge. Because rain would interfere with the drying process, this preparation is usually done in the summer.

Milk, Rice, and Sweet Potato

The recipe name for milk food is "masse." To prepare it, the milk is left in a mud pot for 24-48 h. The whey is then removed, and the remaining thick "milk" (i.e., curd) is used as a weaning food. Goat's milk is used for this purpose; when cow's milk is available, it is used as a weaning food, but is not fermented. Rice is not usually fermented; on those occasions when it is fermented, the mode of preparation is similar to that used for maize and millet. Sweet potato is not fermented as such, but is used to assist in the fermentation of other foods.

Traditional Porridges

"Mahewu"

To prepare "mahewu," maize flour is cooked in water for 1.5-2 h and cooled. A little wheat flour, potato, sugar, or sweet potato is then added. This mixture is incubated for some time to produce "mahewu," a very popular beverage in the south and lately introduced in the north.

"Chicucumuca"

Fresh corn or millet is washed and ground to a fine flour. This flour is cooked with water and cooled to make a soft porridge that is later inoculated with wheat flour, potato, sweet potato, or sugar, and incubated at room temperature. Although this mode of preparation is similar to that used for "mahewu," "chicucumuca" is thicker and is eaten rather than drunk.

"Shinkwa"

Fresh maize is washed and ground to a fine flour. Sugar is added if available along with a little water to make dough. The dough is shaped into balls, rolled up inside maize leaves, and cooked in a pan of boiling water for 1-1.5 h. If no leaves are available, gunny bags can be used.

"Uputu"

This is an alcoholic beverage, made with maize, millet, or sorghum. The grain is soaked in water for 24 h, after which it is removed from the pot and drained. It is then put in a wooden box or container and covered with a cloth. When it begins to sprout, it is divided into two equal parts. To one part is added maize flour, rice, and warm water; this mixture is left for 24 h, after which it is ground in the same water, boiled, and cooled to make a soft porridge. The second part is pounded to a flour that is stirred into the soft porridge; the mixture is then incubated and cooled. The liquid that is separated out is called "uputu."

Industrial Production of Baby Food

During 1983, 900 t of a baby food called "milk flour" was imported at a cost of 120 MZM/kg (in March 1988, 202 Mozambican meticais [MZM] = 1 United States dollar [USD]). To decrease imports, the government of Mozambique is currently studying a project for industrial production of baby foods (State Secretary of Food Security 1987). The main objective is to provide a baby food at a low price that would meet about one-third of the daily nutritional recommendations, assuming that another third is met by the usual home diet and the final third by breast milk. The original objective was a production of 2000 t of baby food per year on a national scale; because of problems with supply, transportation, and the infrastructure of production, this objective was later discarded.

At present, a project is being developed in the province of Gaza, near the areas of cereal production. This project, similar to models in Benin and Sierra Leone, would allow for the testing of alternative foods and provide valuable experience in this field. There are, however, certain problems that could develop: food production would total about 30 t/year, beginning in 1988; this would cover only 1200 of the 63,580 weaning children in the province and would not, therefore, substantially alleviate weaning malnutrition in the area; the project would, moreover, introduce a new, relatively costly feeding habit and stimulate a demand that the government would have difficulty in fulfilling. One solution to this problem might be to concentrate the utilization of this food on malnourished and high-risk children (i.e., those with growth-faltering); this possibility is currently under study.

Data from Table 8 reveal that the cost of the baby food would be about USD 0.93 per 500-g package, or, assuming a consumption of 2 kg per child per month, USD 3.72 per baby per month. This represents 19.89% of one minimum statutory salary in Mozambique; the data also show, however, that 2 kg of corn grain cost USD 0.13 or 0.72% of one minimum statutory salary. We see, therefore, that the baby food is about 28 times more expensive than corn grain.

There are, however, a number of potential advantages. Once production has risen to 1000 t/year, it would be possible to avoid the importation of baby food; experience could be gained on industrial processing of new foods, particularly of soy; an incentive would be provided for soy production; and models of self-sustaining production would be developed that could be used in the medium term, when the country is in a position of organizing large-scale baby food production and distribution.

Table 8. Baby food industrial production: types and cost.

	Type A[a]	Type B[b]
Composition		
Corn (%)	60	60
Sugar (%)	15	15
Soy (%)	25	-
Beans (%)	-	10
Groundnuts (%)	-	15
Energy (kcal/100 g)[c]	387	389
Protein (g/100 g)[c]	11.2	11.6
Estimated cost (MZM)[d]		
500-g package	372.90	-
2 kg per baby per month	1491.60	54.00
% of one minimum salary	19.89	0.72

Source: State Secretary of Food Security (1987).

[a] Type A is industrially produced baby food.

[b] Type B is homemade baby food using fermented corn prepared from grain.

[c] Estimated energy and protein contents per 100 g of corn are 350 kcal and 9.0 g, respectively.

[d] In March 1988, 202 Mozambican meticais (MZM) = 1 United States dollar (USD).

The question remains, however, as to why more adequate weaning diets are not used in Mozambique. Although the reasons vary from province to province, the answers reveal certain common denominators:

- Armed bandits have robbed certain war-displaced populations of all their available food, making them totally dependent on emergency aid.
- Animal sources of protein are unavailable or are too expensive. Inflation has made it increasingly difficult to secure the minimum amount of food needed by a family.
- The war had led to continual displacements of population; many of these people, seeking safety, have migrated to the provincial capitals and have forgotten the old weaning traditions that favoured the use of fermented corn and sorghum.
- Mothers have neither the time, the fuel, nor the food to prepare a special diet for the weaning child.
- Commercially manufactured baby foods are unavailable. In the rare cases when they are available, they are too expensive for many families.
- Some mothers do not know how to prepare adequate weaning foods or how to avoid contamination while cooking.

Proposed Strategy

The following would constitute a feasible approach toward the alleviation of weaning-age malnutrition in Mozambique: creation of incentives for the preparation of homemade weaning foods; utilization of traditional weaning foods and practices; reduction of the mother's workload; optimized use of the little food available at the local level (corn, sorghum, cassava, and green leaves); and minimization of extra costs for the family.

The war has had a destabilizing effect on the working of the factories and on the transportation and communication networks; consequently, a food-manufacturing industry as such does not exist in Mozambique. This makes national or provincial production, distribution, and commercialization of any processed food extremely difficult. Industrially manufactured food is more expensive than that produced locally; were the population to be dependent on the centrally processed food, then government subsidization would be required for those unable to afford commercial market prices. Such subsidization is not feasible under the current financial constraints of the Mozambican government.

On the other hand, village-prepared foods would require an infrastructure (usually a health facility), trained personnel at the village level, and a sustained input of food to the village to complement the local foods. In the present circumstances, it would be difficult to meet these requirements in most parts of the country. Similar projects in other developing countries did not show sustained success. The only remaining alternative, therefore, is to focus on traditional homemade weaning foods.

The advantages to be gained from the use of homemade fermented foods include the following:

- In many rural populations of Mozambique, fermented maize and sorghum have traditionally been the most important of the weaning foods; these fermented grains are also consumed as breakfast cereals by a large proportion of adults.
- In the rural population, the consumption of fermented foods is particularly marked in the lower socioeconomic strata - among families with the highest incidence of malnutrition.
- In Mozambique, homemade fermented food is 20-30 times cheaper and more widely available than any other processed food or any commercial baby food.
- Porridges made with fermented foods have a better flavour and may allow higher total energy and protein intake than those made with nonfermented foods.
- Compared with their nonfermented counterparts, fermented foods seem to show improved nutrient bioavailability.
- Fermented foods can be stored safely under routine household conditions; this allows a lessening of the mother's work load.
- Fermented foods may help to prevent diarrhea.

The domestication of adequate weaning practices should be the major focus of this strategy. It should be remembered that a socialist society may require different approaches than those of "social marketing," used to stimulate demand in capitalist countries. One approach toward the achievement of this domestication would be a program of home visits to mothers, and of discussions among various groups of mothers.

Also of use would be the social communication methodologies, including the mass media, particularly radio (the most widespread medium in the country) and carefully designed posters, the latter to be used by the health facilities and at the village level. The messages thus disseminated must communicate that food is essential to a baby's health and strength. Information could also be provided about "papas," a satisfactory baby food that can be prepared by traditional methods, using fermented corn and green leaves; mothers could be advised about techniques for enriching this food and about recommended frequencies of feeding. The messages should recommend strongly that the growth of all babies be monitored by periodic weighing and that mothers continue to breastfeed for 2 years. Finally, mothers should be warned against contamination and advised to wash their hands before preparing food or feeding their babies.

There should be an early involvement of the following groups: the Mozambican Liberation Front (FRELIMO); mass democratic organizations (in particular, OMM); formal government structures at the central and local levels; the education sector (primary school teachers and students); and the health sector. These groups could all contribute to a developing of content for the mass media messages; they could also help to determine the required frequency for disseminating these messages. In those sectors with specific needs, a stratification of the population would make it possible to allocate the appropriate communication media. Were the program to be incorporated into the day-to-day routine, it would become a permanent feature of Mozambican affairs. A continual monitoring of each local program would be required, with periodic evaluations as to impact, side effects, cost, and contribution to those national strategies controlling malnutrition and social development.

Active participation on the part of members of the community and family is essential to the success of the program. A sensitization of families and community leaders could be achieved with frequent discussions of the issues concerned. There should be regular assessments of the nutritional and health status of the children; those children in the community who are malnourished must be identified; and there must be a greater awareness fostered of the dangers of food contamination and of the importance of continued breastfeeding.

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REINTRODUCING TRADITIONAL WEANING FOOD: SOCIAL MARKETING CONSIDERATIONS

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Abstract *It is likely that inappropriate weaning practices constitute the most significant factor in malnutrition among children. This factor is also the most complex, being dependent on sociocultural, economic, and behavioural matters specific to each community. A review is presented of the many efforts made to improve weaning practices. The review discusses the failure of most of these efforts in making a lasting impact on weaning practice, and consequently on nutritional status. Two factors are discussed in relation to these failures: first, many programs focus on particular weaning foods, rather than on the whole issue of feeding practice; second, the format of the intervention is often such that new weaning practices are not maintained after the completion of the project. The lessons learned from weaning food projects are summarised, with special emphasis on efforts to promote traditional weaning foods.*

The first step to be taken in the improvement of child feeding is a defining of the boundaries of the problem. Is this problem primarily one of nutritional inadequacy, or the much broader one of feeding practice, of which food quality is only one aspect?

The latter problem is clearly the more comprehensive. Feeding practice - including selection of food - is a complex process that is influenced by a host of factors: traditional values and beliefs regarding food and feeding practices, types of employment held by mothers, income levels of households, extent of promotion and marketing of infant food and of breast milk substitutes, attitudes and influence of health services, and exposure to media. Without a thorough understanding of the problem of infant feeding, efforts to introduce new weaning foods or to promote new formulas are bound to fail.

It is important that the community be involved in any evaluation of the problem of child care and feeding. The most valuable lessons are those provided by successful mothers in the community: their experience can offer us solutions that work in specific environments.

It is important, therefore, that in our approach to the problem, we be free from preconceived ideas: the primary objective of the research is to gain insight into the communities' perception of the problem and of its possible solutions. Focus group discussion can be an especially useful tool, often unearthing subtle yet crucial underlying factors that determine attitude and behaviour.

The Communication Plan

Having discovered in the preliminary research that the problem lies in the inadequacy of the food, and that a new food (in this case, perhaps a traditional food that is no longer given) needs to be introduced, we begin to develop the communication plan. Because there already exists a fund of excellent material, we will not deal comprehensively with this topic. Rather, several key issues will be presented that may help program managers to develop a sound communication plan.

Population Segmentation

It is essential to identify those segments of the population that have special characteristics and needs. This will make it possible to design messages specific to particular segments - a directed approach that provides a key to more effective communication.

The way in which the segmentation is done will vary with the nature of the messages to be communicated, and with the local situations. The introduction of a new weaning food, for example, would target the following segments: mothers with babies under 4 months of age, mothers with babies between 4 and 12 months of age, mothers with older children, fathers and other care givers, health workers, and members of women's organizations.

Points of Resistance

Points of resistance - factors militating against the adoption of desired behavioural change - could be social, cultural, economic, or religious in origin. Each segment of the population will have different points of resistance, all of which need to be identified and evaluated. The next step is the development of strategies to overcome those points of resistance.

In attempting to reintroduce a once popular traditional weaning food, the analysis of points of resistance could be extremely helpful. What have been the societal processes leading to the abandonment of the practice? Was availability of the mothers' time a critical factor? What was the image of a traditional food in the midst of a "modernization" process? All this information will be most relevant in developing a strategy to reintroduce the traditional weaning food. It must be kept in mind, however, that we are primarily concerned with current perceptions of these problems, and not with their history.

Developing Messages

Messages should be developed with the full participation of the target segments: this will guarantee the relevance of the messages to the local situations. It is also important that messages adequately address each point of resistance revealed by the preliminary research.

Another important concept is that of "positioning": this is the strategy by which a product is presented in messages. A toothpaste, for example, could take a position as a health product (preventing cavities), as a cosmetic (for "pearl-white" teeth), or as a social aid ("to fight bad breath"). Each of these positions will be most effective with a particular population segment. Similarly, the introduction of a new weaning food may call for the obvious positioning of "health"; this may not, however, be the most effective choice. Alternative positionings, such as "modernity," or "promoting intelligence in the child," should be explored and evaluated. It should be borne in mind that the adjectives "old" and "traditional" may not be the best terms with which to position the concept of a reintroduction of traditional weaning foods.

Once the content of the messages has been determined, the format and presentation should be thoroughly field-tested. Only then should production of the communication materials begin.

Media Planning

The concept of population segmentation is extremely important in media planning: we must first have a clear idea of the particular segment we are attempting to reach, and then determine the medium or media with the broadest coverage of that segment.

Another important concept is the "reach and frequency" concept. Our aim is to reach as much of the audience as possible with adequate frequency. Health and nutrition education tends to stint on frequency (a typical example is the weekly radio lecture). What has proved to be more effective is a well-designed, 1-2 minute message, broadcast 10-20 times/day.

Ensuring Permanency

A prominent weakness in the execution of such nutrition education efforts is the limited time frame. Most of these efforts are implemented as specific projects of 2-4 years' duration; nobody cares what happens afterwards. With such a relatively short time in which to work, it is unreasonable to expect that the new feeding practices will be permanently adopted by the communities.

It is important, therefore, to ensure that the communication activities become part of the routine program activity of the community-based organizations. Survival of the new feeding practices also depends on early involvement of all relevant sectors of local government.

Conclusions

Many efforts to improve young child feeding have failed. These failures seem to stem from the fact that the focus is placed too narrowly on food as such, rather than on the broader issue of feeding practice. A broader approach to problem definition and analysis would allow an identification of critical factors contributing to the achievement of good nutrition status. The dissemination of messages about nutrition could be greatly facilitated through a use of the techniques of social marketing.

DISCUSSION SUMMARY

Weaning Practices and the Development of Weaning Foods

This discussion put forward the need for a pragmatic approach to the development of weaning foods: certain practical considerations were raised, such as the consumer's willingness and ability to pay for improved foods.

With regard to the initiation of feeding with fermented products, it was pointed out that the timing differs from country to country, and even within countries. Two specific issues were raised in connection with the use of fermentation in infant feeding: the first was the question of whether fermentation of foods increases the energy intake of the child; the second concerned the use of sour porridge as a galactologue.

It was agreed that there is anecdotal evidence from many countries to suggest that fermented porridges stimulate breast-milk production. There is, however, little scientific support, and this was identified as an area needing further research. [Editor's note: This topic is further discussed in the paper presented by Mbugua, and a mechanism is postulated.]

In general, it was believed that there is little evidence to show that fermentation increases energy density, although porridges undergo complex changes in viscosity during the fermentation process. [Editor's note: The effect of fermentation on energy density and viscosity is discussed further in many papers in this proceedings; note particularly Mbugua, Keregero and Kurwijila, and the discussion of the effect of the fermentation of cassava on viscosity in the papers by Mlingi, and by Hakimjee and Lindgren.

It was noted that traditional practices can often be developed into technologies that improve infant and child feeding. It was mentioned, however, that primary health care workers are unsure of the position they should take with respect to certain of these practices. In Burundi, for example, mothers feed banana or sorghum beer to their infants; should this be encouraged, discouraged, or ignored?

Educational Approaches

The question was raised as to how, given the competition from commercial companies, we can promote breastfeeding and appropriate weaning practices. In response to this question it was suggested that incentives (such as trips) could be offered to health workers who had successfully promoted breastfeeding; this has been done in Indonesia.

An important issue raised was that of "social marketing." The point was made that this is being promoted as an approach, rather than as a tool that health educators can use in the design of educational programs. In using the jargon of commercialization, we are moving further from a philosophy of development: other disciplines, such as anthropology, adult education, and communications, have more to teach us than does marketing. It was pointed out that different economic systems may require different approaches in education and in communications. The need was emphasized for an inculcation of a sense of community responsibility. Dr Ted Greiner offered the following commentary on social marketing and the use of qualitative research methods:

"Social marketing" is a term applied to a technique of communication. It borrows some methods used in commercial marketing and applies them to social messages. Just as the term "marketing" encompasses much more than advertising or even product promotion, so does social marketing include more than a mass-media campaign. One of its most important aspects is the attempt to learn about and from the "comsumer" or target audience. This involves community-based survey work before, during, and after the design of the communication strategy (which may or may not include a mass-media component). No doubt, like any other attempt at education, it involves the potential for the educator to make the mistake of thinking he is somehow "better" than the "ignorant" target audience. But, at least it has built into it the importance of consulting that audience, and one hopes that involvement, participation, and even the Paulo Frierian ideas of conscientization may not be far behind.

The methods used for consulting the "consumer" in most social marketing programs involve the use of various qualitative research methods. These are also used in commercial marketing, not because they are the best or most precise methods for obtaining the types of information needed, but because they are the most cost-effective. Thos schooled in more quantitative research methods tend to find such imprecise survey methods worthless. On the contrary, such methods are not only necessary, given the limited resources available in developing countries, they can and do provide useful information which cannot be obtained using the more conventional quantitative survey methods.

The controversy between quantitative and qualitative reflects a lack of understanding of what research in a broad sense means. Research is an organized way of learning about reality and truth in the physical world. Ideally, any research method provides information which is both valid and reliable. Valid data mean what we think they mean. Reliable data are found again and again if the same research method is used - food research should be repeatable. In the laboratory and even in some clinical studies, quantitative methods provide both valid and reliable information. But when research moves into the home and the community, i.e., when survey methods are used, quantitative methods tend to fail to achieve a high degree of validity. Particularly when surveys and questionnaires are designed by persons from another culture, misunderstanding complicates and confuses the already oversimplified responses obtained. This is especially true for information that goes beyond simple facts or recall, into the realm of cause, of why things are the way they are. A particular type of question may always elicit the same response, and thus result in reliable data, but the response may not mean what the researcher thinks it does. Community surveys commonly suffer from such a lack of validity when simple interview techniques are used.

An example of how different methods provide different levels of validity is the commonly asked question, "Why did you stop breast-feeding?" Among the most common responses is "insufficient milk." This is duly listed in survey reports, but has little meaning for policy-making or planning because its cause is uncertain. More in-depth interviewing of the type used in certain qualitative research approaches might reveal that "insufficient milk" is really a shorthand way of expressing a complex series of beliefs and motives. Fears, uncertainties, shared beliefs, even attempts to mislead the interviewer (or a portion of the community) may be hidden behind this simple respnse. Infant feeding decisions are often based on a weighing of many factors and this reality simply cannot be expressed in a minute to a complete stranger. The more complex the reality we want to uncover, the more in-depth is the method we will have to employ - all the way to the very slow participant-observer technique used by anthropologists. Clearly, such techniques can never hope to achieve the kind of reliability possible with superficial but rapid interview methods which can be used on large samples. However, more and more researchers are realizing that the best approach for obtaining answers to more complex question is to "triangulate," that is to use several different methods focused on the same issue.

For the kinds of information needed to plan an appropriate and effective communication strategy, researchers have found that "focus group" interviews tend to obtain information which is nearly as good - and in some respects, better - than that obtained by large interview surveys. If resources allow, then focus groups can be complemented by interview surveys.

There was an animated exchange following Aphane and Nilsson's paper on focus group discussion. The question was raised as to the validity of information thus collected. In defense of the method, one speaker suggested that it is usually only one of a number of methods used in a study, and that it can be effective in highlighting issues of concern or possible areas of investigation.

Session III

Fermented Foods in Child Feeding

FERMENTED FOODS FOR IMPROVING CHILD FEEDING IN EASTERN AND SOUTHERN AFRICA: A REVIEW

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Abstract *Malnutrition is common among infants and children in developing countries; the condition results from inadequate dietary intake and from a high incidence of infection, especially of diarrhea. In recent years, there has been increasing interest in the promotion of germination and fermentation as household technologies; these technologies would be used in preparing cereals for infant and young child feeding. An outline is given of the metabolic processes involved, together with descriptions of the preparation of fermented cereals in several countries of the region. The metabolic processes cause changes in pH, synthesis of antimicrobials, viscosity, and nutrient availability; there are, therefore, areas of research that must be explored prior to a widespread promotion of the use of germination and fermentation. Such researches would include quantitative measurement of food eaten (especially during illness), examination of the effects of the metabolic processes on the survival of diarrheal pathogens in household foods, and investigation into those cultural and behavioural factors that affect the choice of household food technology.*

In most countries in the region, more than 30% of young children are chronically undernourished. Most malnutrition is associated with the growth-faltering that occurs in the so-called weaning period (from 6 to 24 months); this malnutrition is associated with a high-bulk, low-energy diet, and with frequent infections, notably diarrhea.

Standard efforts to improve the nutritional status of children in this age group have, by and large, met with little success: mothers have been taught the importance of balanced diets and the use of mixtures of ingredients in the preparation of good weaning foods. A great deal of the advice that has been given is, however, highly impracticable for poor and overworked rural mothers: these mothers have, for example, been advised to feed their children frequently, while at the same time being cautioned to give them only freshly prepared food; mothers who work an 8-h day in the fields, and who have to fetch water and scarce firewood from far away, may understandably reject such advice.

In recent years, attention has shifted in the region to technologies that are accessible to poor families, and that can be used for preparing adequate food for young children; such technologies would use locally available ingredients, and would demand the minimum additional expense and time. Most of the research work has been done in Tanzania, where there has been extensive investigation into the use of germinated grain: it was found that the addition of a small amount of this grain to a child's maize porridge will reduce the viscosity and thereby increase the amount of porridge that can be consumed by the child. This method of preparation was once traditional practice in several countries in the region; it has been replaced, however, by "modern" ways of preparing food for young children.

Less thoroughly investigated is the practice of fermenting cereal porridges with a lactic culture. This process of fermentation has been shown to have several advantages: the porridges become acidic, and there is some evidence to suggest that those bacterial pathogens likely to cause diarrhea cannot survive in such a medium; the acidic porridges may be more palatable to anorexic children; and the porridges can be stored, ready for consumption, for several days.

Current nutrition education in several countries in the region emphasizes the importance of adding fats and oils to children's porridge, and of feeding children frequently; there appears, however, to be little documentation on the amount of fats and oils that small children can digest, or on the question of whether some oils are better than others.

There are a host of traditional practices in young child feeding that have been little investigated. Some of these may be beneficial, or could be modified in a simple way so as to make them beneficial.

There is a particular interest in the region in sorghum, millet, and cassava as crops that are drought-tolerant and well adapted to local conditions; these crops are, however, being replaced by those with less drought tolerance - crops that fetch a better price on the market. There is a need to review the use of sorghum, millet, and cassava in young child feeding; it is likely that many useful traditions exist in this area that could be promoted, together with a promotion of the crops themselves.

This paper seeks to act as a stimulus for an exchange of information and ideas. There are plans to distribute it as widely as possible, in order that feedback may be received from workers who have experience to share. We hope such experience will include research work in the laboratory and in the community, as well as accounts of projects evaluating the use of various food technologies.

The Fermentation Process

An Overview

Fermentation is one of the oldest known methods of preparing and preserving food. Foods have from antiquity been fermented to improve palatability and texture, to extend shelf life, and in some cases to improve levels of safety. Fermentation has evolved largely from a practical need: the process preserves for later consumption fresh food items that would otherwise spoil if produced in quantities too great to be eaten at the height of availability; fermentation is, therefore, widely used in the preparation of vegetables, condiments, meats, and cheeses and other dairy products.

The properties of the fermented food are generally considered more attractive and desirable than those of the unfermented raw materials. In addition to improved external properties (taste, texture, aroma), fermented foods are in many cases improved in their nutritional value and in their storage capability. Generally, traditional methods of manufacturing fermented foods are not complicated and do not require expensive equipment (Djien 1979). Fermentation of indigenous foods is, therefore, considered by many to be an effective, inexpensive, and nutritionally beneficial household technology for communities with food scarcity and malnutrition, especially in the developing world.

The changes that occur during the fermentation process are predominantly the result of enzymatic activity brought about by microorganisms. These microorganisms fall into three major categories: bacteria, yeasts, and moulds. Those that produce desirable characteristics can be distinguished from those responsible for spoilage or toxicity. In fermentation, all microorganisms carry out catabolic processes, altering the organic components of food to obtain energy for their growth. In a single fermentation, many types of microorganisms may be involved, each fulfilling a particular role. Each organism is responsible for a distinct change or series of changes in the entire process. Yeasts are the principal microorganisms involved in the fermentation of breads, alcoholic beverages, and bakery products. Although moulds are the predominant species in cheese fermentation, their role is limited and our knowledge of them scarce. Bacteria are mainly responsible for the fermentation of cereals and of animal products. The two major types of bacteria important to cereal and tuber fermentation are those that produce lactic acid and those that produce acetic acid.

A distinction critical to an understanding of the basic fermentation process is that between aerobic and anaerobic reactions. Because they require air for growth, most species of yeasts, acetic acid producing bacteria, and moulds are aerobic. The lactic acid producing bacteria are sometimes referred to as microaerophilic: by a series of intramolecular oxidations and reductions, these bacteria carry out essential metabolic processes with very little or no oxygen. Because they do not utilize oxygen, the changes that they accomplish do not result in a total breakdown of the food into simple oxides, carbon dioxide, and water; rather, their major end product is lactic acid derived from sugar, and a few other (minor) sugar by-products. These bacteria must ferment a great amount of sugar to supply the energy needed for their growth and reproduction. The lactic acid they produce effectively inhibits the growth of other bacteria that could cause decomposition and food spoilage.

Definition and Characterization

Jay (1978) defines fermentation as "the metabolic process in which carbohydrates and related compounds are oxidized with the release of energy in the absence of any external electron acceptors. The final electron acceptors are organic compounds produced directly from the breakdown of the carbohydrates." Although respiration as we know it results in total breakdown of organic substrates, fermentation results in only partial breakdown; lactic acid producing bacteria lack a functional Krebs cycle. Both processes yield energy, but respiration yields far more energy.

The use of energy (glucose) by microorganisms in fermentation occurs by three pathways:

- the glycolytic (hexose diphosphate and Embden-Meyerhof-Parnas) pathways and alcoholic or homolactic fermentation;
- the heterolactic (hexose monophosphate shunt) and 3-2 split pathways; and
- the mixed acid pathway (propionibacterium).

Each pathway has distinct end products of sugar metabolism. The homolactic fermentation results in lactic acid. Heterolactic fermentations result in lactic acid, acetic acid, ethyl alcohol, carbon dioxide, and other sugars. Lactic acid producing bacteria can be divided into two main groups, based on the end products of glucose metabolism - the homofermenters and the heterofermenters.

The homofermentative pattern is observed when glucose is metabolized, but not necessarily when pentoses are metabolized. The homolactics are able to obtain about twice as much energy from a given quantity of glucose as are the heterolactics.

Carbohydrates, especially simple sugars, provide the most readily available source of energy for fermenting microorganisms. Storage material is broken down into smaller units, with small changes in oxidation-reduction (redox) potential. These simple substrates are then oxidized to 2 or 3 carbon units. Applied to sugars, this stage is known as glycolysis.

Through the glycolytic pathway, glucose is broken down to pyruvate. Pyruvate represents the pivot of the catabolic pathway. In respiration, pyruvate is oxidized and decarboxylated to acetate. In anaerobic fermentation, pyruvate is reduced to lactic acid by the action of lactate dehydrogenase.

Although sugars supply the energy needed for metabolism, other nutrients, including proteins, lipids, vitamins, and minerals, are essential to (bacterial) cell maintenance. Microorganisms, however, particularly bacteria, have little synthetic ability; nutrients must, therefore, be supplied mainly by the fermenting substrate.

Lactic Fermentations

Lactic acid producing bacteria are, with some exceptions, gram-positive, catalase-negative, nonsporeforming spheres and rods. There are four genera of lactic acid producing bacteria: Lactobacillus, Leuconostoc, Pediococcus, and Streptococcus. All require carbohydrates for energy, are unable to synthesize amino acids and growth factors for reproduction, and all produce lactate from hexoses. These bacteria thrive in microaerophilic to anaerobic conditions. Their characteristic rapid production of lactate inhibits the growth of most detrimental, acid-sensitive bacteria in soil and on plant surfaces. All members of the genera Pediococcus and Streptococcus are homofermenters along with some of the lactobacilli, whereas all Leuconostoc are heterofermenters along with some of the lactobacilli. Jay (1978) states that the heterolactics are more important than the homolactics in producing flavour and aroma components, such as acetaldehyde and diacetyl, in foods.

Many lactic acid fermentations are initiated by such spherical bacteria as Leuconostoc mesenteroides and Pediococcus. The rod-shaped bacteria Lactobacillus plantarum and L. brevis normally succeed the spherical bacteria, and lower the pH to the desired level of about 3.6. Ayres (1980) has found that although other genera and species of lactic acid producing bacteria seldom appear in fermenting vegetables, some that are culturally similar appear commonly on plants.

Parameters for Growth

There are four intrinsic parameters critical to the growth of fermenting microorganisms: pH, moisture content, oxidation-reduction potential, and nutrient content. Each of these has a special effect on microorganisms in food.

pH

Most microorganisms grow best at pH values around 7.0; few grow at all below 4.0. Bacteria, particularly pathogenic bacteria, tend to be more fastidious in their pH requirements than are yeasts and moulds. Yeasts and moulds grow in a pH range from 1.5 to 11.0. The pH value of meats and dairy products is optimal for the growth of spoilage bacteria. The low pH of most vegetables and fruits allows for yeast and mould spoilage.

The various species of bacteria in the fermentation process differ considerably in their pH range for growth; most are favoured at neutral pH. The lactic acid producing, acetic acid producing, and propionic acid producing bacteria are favoured by an acid reaction. The acidity they produce in food is lower than the pH tolerance of a large majority of other bacteria, including pathogens. It is this characteristic that makes them so valuable in food preservation (Pederson 1979), and, possibly, in the inhibition of diarrheal pathogens.

Different foods vary in their capacity to resist changes in pH, and therefore in their buffering capacity. The presence of certain buffering substances, such as salts and proteins, permits fermentation to occur without major changes in pH. For example, the buffering capacity of meats, milk, and seeds far exceeds that of leafy or root vegetables. Consequently, considerable growth and acid production may occur in milk without a great change in pH. Although green beans and peas can be fermented by lactic acid producing bacteria, the pH change is so slow that nonlactic bacteria frequently grow and cause spoilage.

Moisture Content

One of the oldest known methods of preserving food is that of drying. Water requirements of microorganisms are now described in terms of water activity (a_w) in the environment. Water activity is defined by the ratio of water vapour pressure of the food substrate to that of pure water at the same temperature:

$$a_w = \frac{\text{water vapour pressure of food}}{\text{water vapour pressure of pure } H_2O} = p/P_0$$

This parameter is related to the relative humidity (RH) of the atmosphere in equilibrium with the food in the following way (Jay 1978): RH = a_w x 100.

The a_w of most fresh foods is above 0.99. Most spoilage bacteria do not grow below an a_w of 0.91. Most spoilage yeasts grow as low as 0.80. As with pH range, the a_w range of yeasts and moulds is larger than that of bacteria. The lowest reported a_w of any bacteria is 0.75.

Moisture requirements are affected by nutrients, temperature, oxygen, and other factors. At any temperature, the microorganism's growth is reduced as a_w decreases. The a_w growth range is greatest at optimum growth temperatures. The presence of nutrients increases the a_w growth range.

Oxidation-Reduction Potential

Microorganisms show varying degrees of sensitivity to the redox potential of their environment. The redox potential of a substrate, expressed as Eh, may be defined as the ease with which a substrate gains or loses electrons. Aerobic microorganisms require positive Eh values for growth, whereas anaerobes require negative values. Sulfhydryl groups, ascorbic acid, and reducing sugars in foods help to maintain reducing conditions. The lactic acid producing bacteria tend to lower the Eh of foods and, thereby, restrict the growth of aerobic microorganisms.

Nutrient Content

To grow and function, microorganisms in food need water, energy, nitrogen, vitamins, and minerals. Moulds and yeasts have lower nutrient requirements than have bacteria. As described previously, carbohydrates in the form of sugars provide the main source of energy. The primary nitrogen sources are amino acids derived from peptides and proteins. In general, most organisms will utilize simple compounds such as amino acids before hydrolyzing larger molecular weight proteins.

In addition to intrinsic parameters, that is, parameters inherent to plant and animal tissues, extrinsic parameters also affect foods and their microorganisms. The most important extrinsic parameter that will be discussed here is temperature. The temperature at which a food is fermented will greatly influence the rate of fermentation, the species of organisms involved, and the microbiological changes that occur. Most of the important food microorganisms are mesophiles.

Lactic acid producing bacteria grow best at about 30-32°C. A few species of *Lactobacillus* involved in milk fermentation grow at 40°C or above. *Leuconostoc mesenteroides* has a lower temperature growth range than other lactics. Certain spoilage organisms of the genera

Pseudomonas, *Flavobacterium*, and *Achromobacter* grow at temperatures near freezing (and often grow in refrigerators). Some organisms, such as *Streptococcus faecalis*, grow over a range from 0 to 30°C or above. Most thermophilic bacteria of importance belong to the genera *Bacillus* and *Clostridium*. Comparing moulds and yeasts with bacteria, we see that the former grow over a wider range not only of pH, a_w, Eh, and nutrient availability, but also of temperature.

In assessing conditions for the growth of fermentation organisms, it is essential to consider all the intrinsic and extrinsic characteristics present at the time of fermentation. Changes in one parameter (e.g., a_w) will influence the effect of another parameter (e.g., temperature). In most traditional processes of fermentation in Africa, ideal conditions have been established over centuries for the growth and production of a highly desirable product.

Fermented Cereal Foods in Africa

Fermented Maize Products

Bacterial fermentation of starch-rich substrates is practiced widely in Africa. Maize (*Zea mays*) and cassava are the most important raw materials. Sour porridges prepared from cereals (particularly maize) may represent the dietary staple in many countries. There are at least 20 different fermented maize products, most of which follow the same basic fermentation process.

Nigerian "Ogi"

"Ogi" is a smooth-textured porridge with a sour taste reminiscent of yogurt. Its colour depends on the cereal base used to prepare it - cream for maize, reddish brown for sorghum, and grey for millet. Although the term "ogi" usually refers in Nigeria to maize porridge, "ogi baba" and "ogi gero" are used to describe sorghum "orgi" and millet "ogi," respectively. The starchy sediment produced from the fermentation process is the "ogi," and is usually marketed as a wet cake wrapped in leaves. Cooked "ogi" porridge is called "pap" all over Nigeria. In different regions, the same product may be called "akamu" or "eko gbona." "Eko tutu" or "agidi" is a gel-like product prepared from "ogi"; it contains less water than does "pap" and is wrapped in leaves. Maize "ogi" is most common in the northern Nigerian states (where most of the maize is grown), whereas millet "ogi" is more predominant in the southern states (Steinkraus 1983a).

Production methods "Ogi" production is traditionally carried out on a small scale, with batches being made 2 or 3 times a week. The maize grain is cleaned, soaked (steeped) in lukewarm water for 1-2 days, then drained, wet-milled and sieved with water through a mesh screen to remove the fibre, hulls, and much of the germ. The filtrate is then allowed to sediment and further ferment for 24 to 72 h at 30 to 32°C, until it becomes sour (Akinrele 1970). The sediment is "ogi," which is either boiled in its supernatant or in water to give "ogi" porridge ("pap"). In commercial practice, the uncooked sediment is drained and sold wrapped in leaves. The shelf life (unrefrigerated) of this product is less than 30 h (Fig. 1).

Control of fermentation To achieve an "ogi" of acceptable flavour, control must be maintained over 2 of the stages of processing: the first of these is the steeping of the whole grain for 24 to 72 h before wet-milling and wet-sieving; if an increase in acidity is desired, the second stage is a further fermentation for 1 to 3 days. The pH of the grain following steeping should be about 4.3 ± 0.2. The final "ogi" with desirable flavour and aroma has a pH of 3.6-3.7, and a titratable acidity of about 130 mg NaOH/100 g product. pH values above or below this level are not acceptable. Studies on the traditional process have shown that the ideal temperature for rapid fermentation is 30-32°C; at 45°C, fermentation is inhibited.

Commercial variations on "ogi" production in Nigeria are usually characterized by differences in the time of steeping and of souring (Akinrele 1970). When warm water is used for steeping, the required fermentation period is about 1 day; when cold water (30-32°C) is used, 3 days of fermentation are required before an acceptable, sour flavour is developed. After 24 h, a steeping of whole grains results in a microflora dominated by the lactic acid producing bacteria. This condition continues for another 48 h. When the grains are steeped for more than 48 h, they can be seen to contain high counts of aerobic organisms that may contribute to the undesirable flavour. This phenomenon is sometimes controlled by fermenting at a higher temperature. The practice in West Africa of steeping whole grains instead of milled maize could be seen as another means of cultivating the desirable bacteria. Studies by Akinrele (1970) have shown that most of the water absorption of maize grains takes place within 24 h (at 30-32°C) and that this length of time is sufficient for the production of lactic acid producing bacteria.

Microbiology of "ogi" fermentation The microorganisms in "ogi" have been isolated and identified. Moulds associated with the surface of fermenting maize include Cephalosporium, Rhizopus, Oospora, Cercospora, Fusarium, and Aspergillus. All are eliminated after 6 h of steeping. The bacteria are Corynebacterium, Clostridium, Enterobacter cloacae, and L. plantarum, L. brevis, and Acetobacter. Isolated yeasts include S. cerevisiae, Rhodotorula, and Candida mycoderma.

The predominant bacteria in the porridge fermentation is L. plantarum, also responsible for the production of the main acid, lactate. Corynebacterium is thought to hydrolyze maize starch to form organic acids, whereas S. cerevisiae and C. mycoderma influence flavour acceptability (Steinkraus 1983b).

Organoleptic properties of "ogi" In "ogi" production, as in most cereal fermentations, the main objective is to enhance the flavour by making it acidic or sour. In cultures where cereal fermentation is practiced, the soured product is preferred to the bland-tasting food made from unfermented grain. In some populations, the "ogi" slurry is boiled in its own wash water to increase the final acidity. The predominant volatile and nonvolatile acids in "ogi" are lactic and acetic acids, respectively; there are trace amounts of formic and butyric acids. Volatile and nonvolatile acids give the most acceptable sour flavour in percentages of 0.65 and 0.11, respectively (Banigo and Muller 1972). A final boiling of the "ogi" in its wash water increases the overall amount of acid; the ratio, however, of volatile to nonvolatile is not altered.

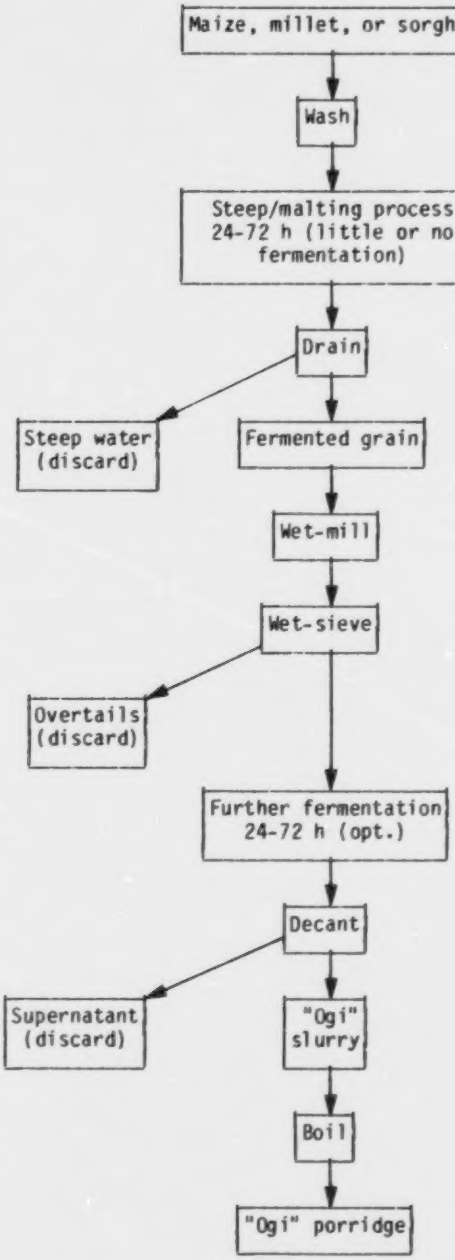
Maize, millet, or sorghum
Wash
Steep/malting process 24-72 h (little or no fermentation)
Drain
Steep water (discard)
Fermented grain
Wet-mill
Wet-sieve
Overtails (discard)
Further fermentation 24-72 h (opt.)
Decant
Supernatant (discard)
"Ogi" slurry
Boil
"Ogi" porridge

Fig. 1. Traditional "ogi" preparation (Steinkraus 1983b).

Fermentation markedly affects the swelling and thickening characteristics of the starch component of maize flour suspensions. It is thought that this is primarily caused by the presence of lactic and acetic acids. There is significance both in the changes in texture that occur during fermentation, and in the change in the gelation period of maize flour after fermentation. Ideally, the final product is a smooth, fine paste, free from fibre and hulls, and low in germ.

Use of "ogi" in Nigerian culture "Ogi" as porridge ("pap") has traditionally been the main food for infants and young children, and a major breakfast cereal for adults. "Ogi" is much cheaper than imported commercial baby foods. Sugar or condensed or powdered milk may be added to the porridge, according to taste. Adults consume "ogi" with meat stew and fried plantain, with fried bean cake, with steamed bean cake ("moin-moin"), or with bread and fried egg. "Ogi" can be used to thicken soups and stews.

Although nutritional information on the consumption of "ogi" is scarce, it is estimated that in some states, this consumption represents one-third of total daily caloric intake. In urban areas, and in rural areas where modern ideas and practices are becoming more influential, there is a trend away from consumption of traditionally prepared, cheap foods toward more expensive processed foods. As more women in the urban areas enter the work force, demands on their time increase. Although traditional foods such as "ogi" may be cheaper than commercially processed foods, they are also more perishable, and their preparation more time-consuming. These factors should be taken into account in any efforts to encourage the consumption of traditional foods.

South African "Mahewu" ("Magou")

"Mahewu" is a nonalcoholic, sour beverage popular among the Bantu people of South Africa; it is produced on a large scale, and its consumption is high among the junior staff members of mining companies and industrial firms. Akinrele (1970) has described "mahewu" as the Bantu equivalent of Nigerian "ogi," with this difference: in "mahewu," the souring is caused by bacteria that are introduced through the addition of wheat flour. "Mahewu" is classified by most as a beverage, whereas "ogi" is considered a porridge; Novellie (1982) notes, however, that often the only difference between sour beverages and sour porridges is the concentration of the cereal. "Mahewu" contains 8-10% solids and has a pH of about 3.5, with a titratable acidity of 0.4-0.5% (identified as lactic acid). Commercially, it is often produced in dry or concentrated form to facilitate distribution and marketing.

Steps in "mahewu" production Traditionally, "mahewu" is made by mixing about 450 g maize meal with 3.8 L of water, boiling until the porridge is cooked (about 1.5 h), cooling, and adding a small amount of wheat flour (about 5% of the weight of the maize meal). The wheat flour provides the inoculum, and is the source of growth for the spontaneous fermentation. The bacteria in the porridge rapidly converts the sugars, derived from the starch by wheat amylolytic enzymes, into lactic acid. Following inoculation, the "mahewu" is incubated at about 30-35°C for 36 h, after which time the desired sour flavour has developed (Fig. 2).

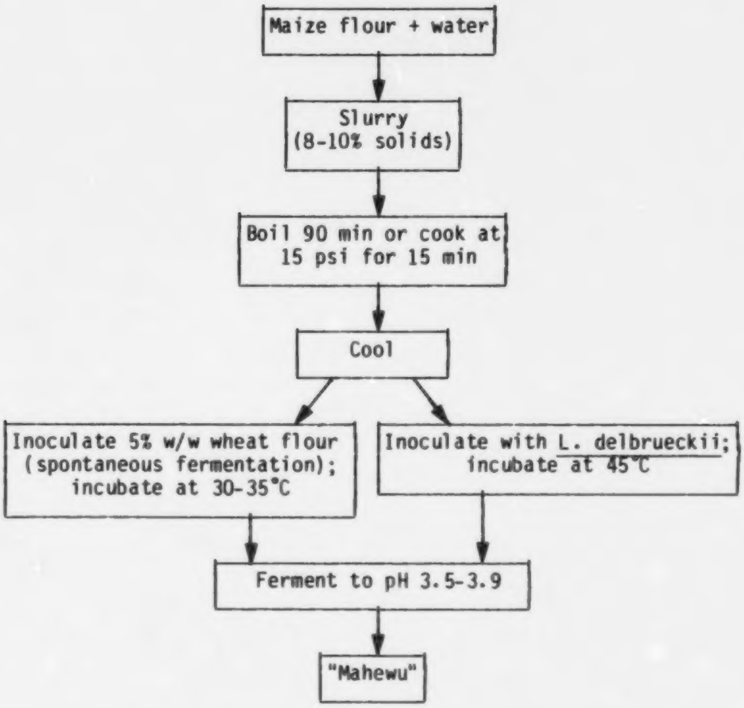
Maize flour + water
Slurry (8-10% solids)
Boil 90 min or cook at 15 psi for 15 min
Cool
Inoculate 5% w/w wheat flour (spontaneous fermentation); incubate at 30-35°C
Inoculate with L. delbrueckii; incubate at 45°C
Ferment to pH 3.5-3.9
"Mahewu"

Fig. 2. Production of "mahewu" (Steinkraus 1983b).

According to Schweigart and de Wit (1960), the souring time of "mahewu" is too long and too irregular for traditional methods to be used in industrial-scale production. Moreover, these methods can produce the growth of undesirable bacteria that cause secondary fermentation, the products of which (e.g., acetic and butyric acid) spoil the taste of the food. Schweigart and de Wit (1960) describe an improved method of producing "mahewu" under controlled conditions: wheat flour (a source of growth factors) was added to the maize-water mixture; the suspension was then inoculated with L. delbrueckii or L. bulgaricus. Both strains were shown to have a high capacity for producing lactic acid, and both grew optimally at temperatures high enough (45-51°C) to suppress the propagation of acetic and butyric acid-producing bacteria (Schweigart and de Wit 1960).

For industrial-scale production of "mahewu," a coarsely ground white maize is used as a substrate, together with an inoculum comprising pure cultures that have been isolated from traditionally made "mahewu" and cultured on coarsely ground whole wheat flour. The maize meal slurry (8% solids) is cooked by boiling for an additional 45 min. The thick slurry is then cooled to 47-52°C and inoculated with the starter. The fermentation proceeds without controlling for temperature for 22 to 24 h, during which time the pH falls to between 3.65 and 3.95. A thinner "mahewu" can be made by adding wheat flour; a thicker product, by using either less wheat flour or more maize meal (Novellie 1982). The fermented product is enriched with soybean meal, sugar, fish flour, whey, or buttermilk powder and yeast. Schweigart and de Wit (1960) emphasize the importance of adding high-quality protein for the development of the cultures. Milk protein, for example, furnishes the quantities of essential amino acids necessary for the fermentation. The mixture is spray-dried to a moisture level of 3.5-4%; it then has a storage capability of a year or more. The dried powder is mixed with water for consumption.

Microbiology of "mahewu" fermentation There are two factors of major importance in "mahewu" fermentation: the nature of the microorganisms present in the wheatmeal, and the fermentation temperature. The optimum incubation temperature for spontaneous fermentation (i.e., by the traditional method) appears to be 35°C, and the predominant microorganism is *Streptococcus lactis*. This method has, however, the disadvantages reported by Schweigart and de Wit (1960).

To overcome the shortcomings of the traditional "mahewu" production, a great deal of research has been devoted to the use of starter cultures. Experimentation with various microorganisms, including *L. delbrueckii*, *L. bulgaricus*, *L. acidophilus*, and *S. lactis* showed that the most successful organism for producing acid was *L. delbrueckii*. At the recommended temperature of 45°C, *L. delbrueckii* grows rapidly; other, undesirable bacteria are unable to grow at such a high temperature. Schweigart and de Wit (1960) found that *L. delbrueckii* cultures develop their greatest activity when they are inoculated onto a fresh medium every 8 h. The cultures show a less vigorous growth when they are transferred after 12 h, and almost no activity after 24 h. An adapted culture of *L. delbrueckii* used with a suitable buffer has been reported to decrease the fermentation time to 3 h (Steinkraus 1983b).

In large-scale, bulk fermentations, it is preferable that the *L. delbrueckii* culture be adapted to growth on a maize meal broth before inoculation. The culture must be mixed thoroughly with the porridge; this is difficult when the porridge is very thick. The addition of a high-quality protein source, such as skim milk powder or whey powder, is essential, because it provides the amounts of essential acids required for the fermentation process. Such acids are limiting in the cereal proteins, particularly in maize protein, in which there may be insufficient lysine. If whey is used as the source of protein, *L. bulgaricus* (which uses lactose) is desirable as the principal fermenting organism. Other sources of high-quality protein that can be used include yeast, soy flour, and fish flour.

The addition of buffer salts to the medium is essential for the production of sufficient lactic acid. Both whey and phosphates (dicalcium phosphate) serve as buffers, preventing the pH from falling to detrimentally low levels - levels that would prevent the production of lactate. When the pH is maintained at 3.8-4.0, the production of acid is increased. Peptone appears to be an indispensable addition to the medium.

Wheat flour has been found to act as a stimulant for bacterial growth. Because wheat is imported into South Africa, it was desirable to find a substitute for wheat flour or meal. Based on the understanding that the active agents in the wheat flour were probably the enzymes, Schweigart and de Wit (1960) found that wheat bran, richer in certain enzymes than wheat meal, could provide a substitute. It was found that 0.5 to 1% wheat bran added to the slurry had the same effect as 5% wheat meal. Because the enzymes in the bran responsible for the stimulation of growth are heat-labile, the bran should not be used at high temperatures; it should not, therefore, be added through the autoclave process, but rather after the cooking and cooling.

Normally, the final "mahewu" product contains 8-10% total solids, 7-9% protein, and less than 0.5% v/v ethanol. Lactic acid production reaches a level of 0.5% total acidity and a pH of about 3.5. The preparation of a concentrated "mahewu" (with 24% solids) requires about 8 h of fermentation; three times as much lactic acid is produced with this method as was produced during the 3-h fermentation.

Organoleptic properties of "mahewu" Among the Bantu, the preferred "mahewu" generally has an acidity of 0.4-0.45% lactic acid, a pH of 3.5, and a solids content of 8%. A clean, sour flavour (from lactate) is preferred, and acetic and butyric acid should not be present. Because alcohol does not improve the flavour, its formation during fermentation should be avoided. A dried "mahewu" should readily mix with water to give a stable dispersion with a consistent, home-brewed flavour. It is widely consumed by young children and adults.

Kenyan "Uji"

In eastern Africa, a suspension of maize, millet, sorghum, or cassava flour in water is fermented before or after cooking to make a thick, creamy porridge. The terms "uji" and "okamu" are used, confusingly, for both nonfermented and fermented forms. In this paper, the term "uji" is used for the fermented form only. "Uji" is consumed widely in Tanzania, Uganda, and Kenya, and there are many ethnic variations on the same basic drink.

"Uji," consumed at breakfast and at lunch, is widely used as a food for infants and for young children. Fermented "uji" is believed by some to enhance lactation. It can be served at any time of the day in traditional (rural) African society, either alone as a thirst-quenching or breakfast drink, or with tea and bread. It has a long history in East African tribal custom, both as a ceremonial and a symbolic drink at weddings, funerals, dances, and other functions.

Over the last 2-3 decades, "uji" consumption in Kenya has declined from about 3 L/person per day to as low as 0.2 L/day (Mbugua 1981) in urban areas. This decline in consumption is thought to be the result of several factors: the lengthy time required for preparation, the shortage of some essential cereals, and the availability of cheaper, easier-to-prepare substitutes, such as tea and coffee. Today, most consumption occurs at breakfast or lunch.

Production of "uji" The basic "uji" can be made with maize, sorghum, millet, or cassava, or a blend of two or more of these flours. If corn is mixed with sorghum, it is usually in the ratio of 4:1. The cereal is ground to a flour and mixed with water to form a slurry at a concentration of about 30% w/v. The slurry (without inoculation) is left at 25°C (room temperature) or near a fire, and is fermented for 1 to 3 days, until the acidity reaches about 0.3% as lactic acid. It is then diluted to about 10% solids, boiled, further diluted to 4-5% solids, sometimes sweetened with sugar, and consumed while still warm. The pH of the final product is about 3.8-4.4.

There are variations to this process in different parts of Kenya. The fermented cereal suspension may be dried in the sun and the granulated powder hydrated and then used to make "uji," as is the case in parts of western Kenya. In the Rift Valley of Kenya, the flour is moistened to make a paste that is packed in leaves, left in the ground for 3 to 5 days to ferment, and then sun dried. The resultant crumbled powder is used to produce "uji." In the Tana River district, whole maize is pounded with a mortar and pestle, suspended in water, and the heavy sediment extracted. The moist sediment is incubated for 3 days in a warm place and then added to cooked "uji," prepared from the suspension of supernatant. In parts of central Kenya, a maize-millet flour mixture in water is incubated in a warm spot for 2 to 3 days. Small portions of the fermented solution are taken out each day as needed, further diluted and cooked. In general, the maize-millet blend is preferred to maize flour alone (Fig. 3).

Microbiology of "uji" Microbial studies of the various flours used to make "uji" have revealed that the major constituents in the cereal flours are coliforms, yeasts, and moulds. Lactobacilli constitute only a minor ingredient (less than 10 organisms/g flour), regardless of the cereal studied. During the first 16-24 h of spontaneous fermentation, coliforms predominate. The lactobacilli then begin to dominate, and sufficient acid is produced to cause a reduction in the number of total coliforms. If millet is used instead of sorghum, lactobacilli dominate the fermentation from the outset.

Inoculation of "uji" with L. mesenteroides immediately restricts growth of undesirable coliforms. Similarly, inoculation of "uji" with mixed lactobacilli cultures isolated from fermented "uji" results in rapid acid production and inhibition of coliforms (Mbugua 1981). In the typical "uji" fermentation, L. plantarum is the predominant species of lactobacilli present. "Uji" fermentation requires 32-40 hours, and the final pH is between 3.5 and 4.0. Total acidity of the finished product is between 0.55 and 0.62%, as lactic acid.

Ghanaian "Kenkey"

In Ghana, sour maize dough is used to make a variety of similar products, the most popular being "kenkey." This is a fermented maize dumpling, and a staple food for a large proportion of Ghanaians, particularly in the coastal areas. "Kenkey" is made in a ball or cylindrical form, and is usually wrapped in layers of plantain or maize leaves. There are numerous varieties of "kenkey," differing from tribe to tribe; some varieties contain additives such as salt, sugar, or sweet potato; the types of "kenkey" also vary in shape and method of wrapping. Although maize is by far the preferred substrate, "kenkey" can be made entirely from sorghum.

Production of "kenkey" In the preparation of "kenkey," shelled maize grain is first cleaned by winnowing and thorough washing. It is then soaked for 1 to 2 days at about 30°C, drained, and ground into a meal. The meal is mixed with water to form a dough, then left in vats

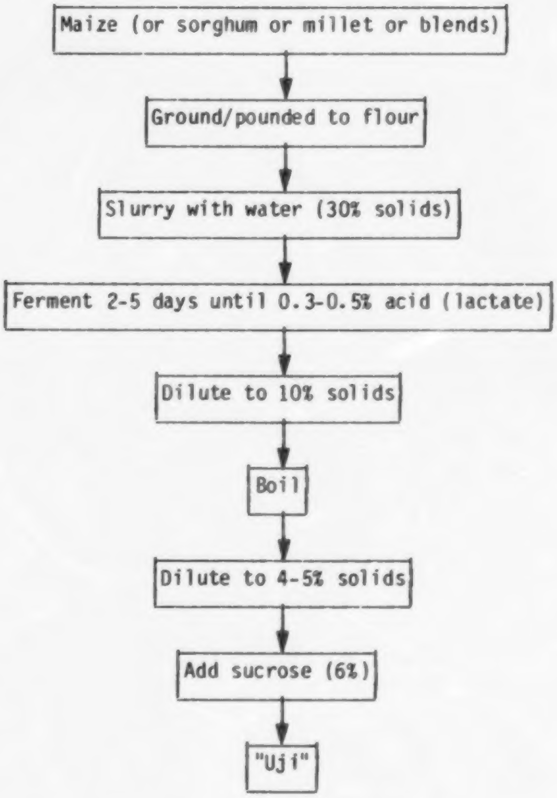
Maize (or sorghum or millet or blends)
Ground/pounded to flour
Slurry with water (30% solids)
Ferment 2-5 days until 0.3-0.5% acid (lactate)
Dilute to 10% solids
Boil
Dilute to 4-5% solids
Add sucrose (6%)
"Uji"

Fig. 3. Production of "uji."

to undergo spontaneous fermentation for 2 to 3 days. If the fermentation vats are left uncleaned from the last fermentation, the residue acts as a starter.

Before being cooked, the fermented dough is divided into three equal parts. One part is slurried with additional water and boiled into a thick porridge called "aflata"; this porridge is then added to the remaining dough, and the mixture is shaped into balls, wrapped in leaves, and boiled in large iron pots. The proportion in which cooked and uncooked fermented dough are mixed can vary according to local taste (Fig. 4).

Microbiology of "kenkey" During the initial stages of "kenkey" fermentation, fungi, particularly *Aspergillus*, *Rhizopus*, and *Penicillium*, and gram-negative bacteria (that at first are not numerous) begin to disappear. Between 9 and 24-36 h after fermentation begins, acid-forming streptococcaceae rapidly multiply. The population decreases continually within the dough up to about the 4th day. On the surface of the dough, the population of streptococcaceae fluctuates and reaches a peak on the 14th day. *L. brevis* and other

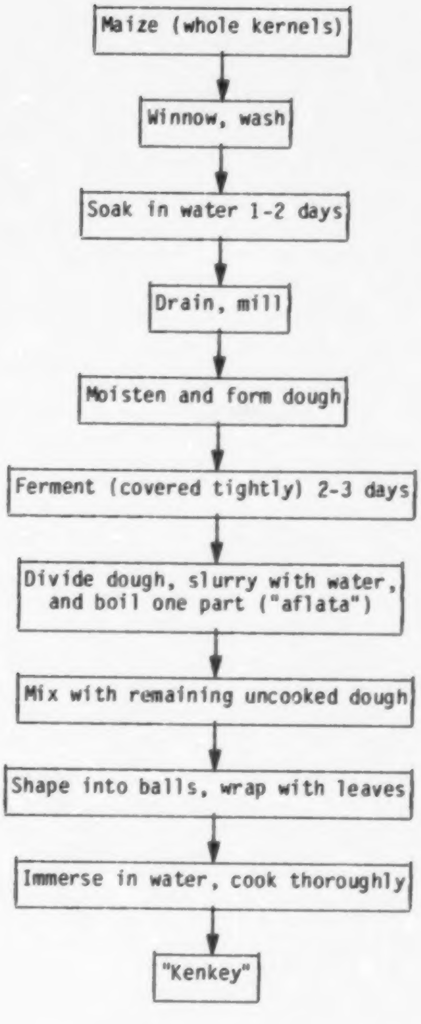
Maize (whole kernels)
Winnow, wash
Soak in water 1-2 days
Drain, mill
Moisten and form dough
Ferment (covered tightly) 2-3 days
Divide dough, slurry with water, and boil one part ("aflata")
Mix with remaining uncooked dough
Shape into balls, wrap with leaves
Immerse in water, cook thoroughly
"Kenkey"

Fig. 4. Production of "kenkey."

lactobacilli, as well as Acetobacter and Clostridium, have been isolated from the dough. Wild yeasts, including Saccharomyces, also begin to develop on the surface after the 1st day. At the end of the 4th day, a thick slimy layer of yeasts is detectable on the dough's surface. These yeasts apparently form the predominant microorganisms during the later phase of fermentation. Among the bacteria, the most common that has been found is Pedioccocus cerevisiae. Heterofermentative lactobacilli belonging either to L. mesenteroides or to L. fermentum were also found.

Biochemical changes The production of "kenkey" closely follows the growth of gram-positive, catalase-negative cocci. The levels of acidity rise rapidly inside and outside the dough; after the 2nd day, however, the surface acidity tends to fluctuate. Inside the dough, the acidity tends to level off and remain constant up to the 4th day of fermentation. During fermentation, the pH of the inside of the dough falls to 3.5-4.1. On the surface, the pH drops to 4.5 on the 2nd day of fermentation and then begins to rise again.

Organoleptic properties "Kenkey" has a characteristic flavour and aroma, strongly representative of diacetyl, acetic, and butyric acid. Most of the aroma comes from the surface layers of the dough. The husk of the grain is unaffected by fermentation and serves as a good source of fibre. The grain grit is partially hydrolyzed to a carbohydrate of lower molecular weight; this carbohydrate gels on boiling, and may make the product more digestible. It is likely that by esterifying organic acids and alcohols, yeasts are most influential in giving "kenkey" its characteristic aroma. Various forms of "kenkey" are widely used for the feeding of infants and young children in West Africa.

Fermented Cassava Products

Cassava is used as a dietary staple by millions of people. Although it is rich in calories, it is rather low in protein and in other important nutrients. One of the advantages to be gained by the fermentation of cassava is an increase in protein content.

West African "Gari"

"Gari" is a starchy food made from cassava tubers. These tubers are first peeled, and the pulp grated. The juice is then squeezed from the pulp by pressing the latter in burlap sacks. The remaining pulp is left for 3 to 4 days for natural fermentation (Djien 1979). The resulting cake is heated on an oiled hot plate; the granular yellowish material obtained is called "gari" (Ngaba and Lee 1979). A related product - cassava flour - is made by soaking whole tubers in water for a few days, peeling and cutting them, then drying to 13% moisture, and grinding and sieving.

In Nigeria, "gari" is primarily consumed in a meal form called "eba." The "gari" is stirred in boiling water to produce semisolid elastic dough. This dough is rolled with the fingers into balls of 10-30 g and dipped into a stew or sauce with meat, vegetables, or fish, and palm oil. It is the staple diet of many in Nigeria, eaten at least once or twice a day.

In Burkina Faso, fermented cassava is sometimes used to make "to," the staple food of the Burkina-be. Cassava-based, "to" is eaten mainly in the south, where cassava production is greatest. "To" is also eaten in the form of small balls, formed with the fingers and dipped into a meat or vegetable sauce. In Burkina Faso, cassava flour is occasionally used to make weaning porridge for infants.

In some West African countries, "gari" may be eaten without stew, especially during the hot season. It can be soaked in cold water with added sugar, salt, or spices, or eaten with coconut or with other foods.

Preparation of "gari" "Gari" is usually prepared in the home by women in rural villages. The cassava root is the major substrate. The brown outer skin and inner whitish layer of the cassava are removed during processing. The central fleshy portion is removed and grated to a fine pulp. The pulp is placed in bound burlap sacks and compressed with heavy poles, stones, or wood. The sacks are left outside for up to 4 days to allow the mash to drain and ferment.

The fermented pulp is semidry (60% moisture) and harsh. It is sieved to remove coarse fibres, and the finer remaining grains are toasted on shallow iron pots. This dries the mash to about 20% moisture. In some regions, palm oil is added during the toasting; this gives the "gari" a yellowish colour. The toasted grains are sieved again and stored in open enamel basins (Fig. 5).

Microbiology of "gari" fermentation Cassava fermentation is primarily caused by lactic acid-producing bacteria. Lactobacillus plantarum has been found to produce the most "gari"-like flavour in mixed culture. The cassava fermentation appears to follow a typical lactic acid fermentation. Although a variety of microorganisms are present at the beginning, as fermentation progresses, the growth of lactic acid producing bacteria overtakes that of the other bacteria. The fermentation occurs at about 35°C. In 3 days of natural fermentation, the pH of fresh cassava falls from about 6.2 to 4.0. Titratable acidity increases from an initial level of about 1.2 mg NaOH/g in fresh cassava to about 3.4 mg NaOH/g after 3 days. When L. plantarum is used as the inoculum in controlled fermentation, the pH reached after 36 h is about 3.6. When a Streptococcus sp. is used, the final

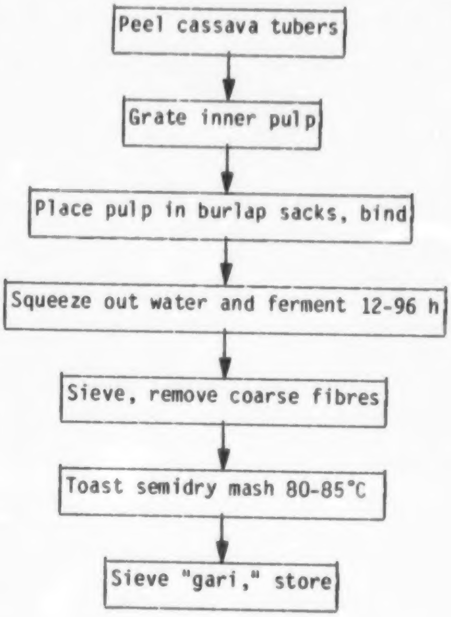
Peel cassava tubers
Grate inner pulp
Place pulp in burlap sacks, bind
Squeeze out water and ferment 12-96 h
Sieve, remove coarse fibres
Toast semidry mash 80-85°C
Sieve "gari," store

Fig. 5. Traditional production of "gari."

pH is about 3.9. When a mixed culture of L. plantarum and Streptococcus is used as the starter, the final pH does not drop below 3.7. It appears, therefore, that Streptococcus should be used with a strong acid producer.

Fermented Sorghum and Millet Products

Sorghum and millet are staple crops in many African countries, particularly in the drier regions. Although in some countries their consumption has been replaced by rice or maize, sorghum and millet are adaptable to an extremely wide range of ecological conditions and, therefore, remain important in Africa, where they are used in a number of traditional recipes.

Traditionally, sorghum and millet are used to make stiff porridge, thin porridge, and a wide range of fermented beverages, including local beers. For the most part, sorghum and millet are grown on a subsistence basis. In areas where beer production is important, however, sorghum is produced commercially, and much of the yield enters formal market channels. Some of the traditional dishes described previously ("uji," "ogi," and "kenkey") can be made with sorghum, millet, or a mixture of the flours from these cereals and maize.

"Bogobe" (Sorghum Porridge) of Botswana

"Bogobe" is a traditional porridge dish of Botswana, made from fermented and unfermented sorghum meal. The fermented "bogobe," called "ting," is usually eaten in the morning and evening. Unfermented "bogobe," called "mosokwane," is eaten at lunch. Both "ting" and "mosokwane" may be eaten with meat and with vegetables.

"Bogobe" is prepared using a starter that is made by fermenting a small amount of sorghum meal in water for 48 h. About 30 g of starter is mixed with 300 g of sorghum meal. The meal is prepared by adding sorghum flour (called "bopi," gritty in texture and derived from dehulled, winnowed grain) to a three-legged pot of boiling, salted water and cooking for about 1 h. The resultant consistency should be that of a thick paste. When the mixture is cool, 50% is transferred to a clay pot (used for fermenting); often there is starter material clinging to the interior of this pot. Some 250-300 mL warm water is added to the meal-starter mixture. The mixture is stirred to make a slurry, then covered and allowed to ferment for 24 h. To make the porridge, the fermented meal is cooked for 12 to 15 min, with frequent stirring, in 1.5 L boiling water. "Mosokwane," the unfermented porridge, is made using 1 part sorghum meal to 4 parts water. The meal is cooked for 20 to 30 min in boiling water, with frequent stirring (Boling and Eisener 1981).

"Nasha" (Sorghum Porridge) of Sudan

"Nasha" is a traditional Sudanese porridge made from fermented sorghum and millet. Although it is consumed by all age groups in Sudan, it is best known as a baby food. The fermentation is lactic acid and alcoholic. The microorganisms involved in the fermentation have been identified (Monawar and Badi 1986) and include the lactic acid producing bacteria Streptococcus, Lactobacillus, and the yeasts Candida sp. and Saccharomyces cerevisiae. Although researchers in

Sudan have found that the microbial load reaches its peak at 6 h, the traditional fermentation lasts about 12 h, producing the preferred flavour. After 12 h of fermentation at 40°C, the pH drops to about 3.7. Longer fermentation (24 h) results in a higher pH (4.0). The acidic taste is more acceptable among the Sudanese, especially for sick children. It is felt that the taste buds of sick children are stimulated by the sour taste; sometimes the sourness is increased by the addition of lemon juice (Monawar and Badi 1986).

"Obusera" (Millet Porridge) of Uganda

"Obusera" is a traditional fermented porridge made from millet. There are three main variations in the preparation of "obusera." The methods differ in the agents used for fermentation. The simplest method of preparation utilizes germinated millet flour for the agent. Millet seeds are soaked in water overnight, removed the following day, and left to germinate in a container, usually of banana leaves. The germination takes about 4 days, or less if the millet is put in the sun. The millet must be kept moist throughout the germination. After the millet has germinated fully, it is thoroughly dried and ground; the germinated millet is then stored in a dry place, ready for use.

To make the "obusera," a millet porridge is first made. This is a very thick porridge, cooked for a long time. A crust forms on the top and the porridge is allowed to cool. When it reaches room temperature, the germinated millet flour is added. The mixture is stirred well until it breaks down and becomes watery. When cool, it is put into the container from which it will be used. It is fermented for 2 days, and consumed on the 3rd day. By the 4th day, the drink begins to turn sour, and sugar may be added to sweeten it.

In another mode of preparation, a dough made from ungerminated millet flour is used as the agent. Some flour is made into a thick dough, wrapped in banana leaves, and cooked in the hot ashes of a fireplace. It is left until dry on top and thoroughly cooked (about 30 min). The "obusera" is then made in the same manner as described earlier. Once the millet porridge is cooked and cooled, the crust of the agent is crushed, and the cooked dough crumbled into small pieces. This is added to the porridge, stirred, cooled, and transferred to the fermentation container.

A third, more complex variation of "obusera" employs banana juice as the fermenting agent. Ripe bananas are crushed with elephant grass until the juice is separated out. A little water is added, and the juice is boiled, cooled, and then mixed with the cooked millet porridge. This "obusera" can be prepared in the evening and consumed the following day. It is very sweet and palatable; by the 3rd day, however, it becomes alcoholic. The "obusera" made from banana juice is very popular in certain parts of Uganda. Because it has been thoroughly boiled and is therefore free of germs, it is thought to be an excellent drink. It is especially popular among Christians as a nonalcoholic substitute for beer.

"Obusera" is considered a nutritious and very strengthening drink. Among the Banyoro, Batooro, and Acholi tribes, it is used to feed children of all ages, sick people, and women about to be married. Because there is no need for frequent cooking, it is preferred to ordinary porridge. Its cool, refreshing taste is very popular among agricultural workers, particularly during periods of heavy work, such as planting and cotton-picking. Because the porridge does not spoil, enough can be made to last 4 to 5 days; it can then be taken into the fields by the workers.

Despite the popularity of "obusera," the traditional methods of preparation are becoming less popular. This may be because of the considerable time and labour required by these methods. Beverages that are easier to prepare, such as tea and milk, are frequently substituted.

In Rwanda, a similar porridge is made using sorghum and millet. To make the agent, sorghum is germinated, then ground and made into a flour. This flour is then added to the millet porridge, as described earlier. The porridge is used to feed young children and the sick. It has been found that sick children are able to drink this porridge; it is therefore easier for them to consume than is unfermented porridge.

"Njera" (from Ethiopia)

This cereal is first prepared as a cold pancake that is then shredded and mixed with water before being left to ferment. It is considered highly suitable for the feeding of infants and young children.

Effects of the Fermentation Process on Food Products

Little is known about the specific effects of the fermentation process on the organoleptic properties of food; these properties include taste, viscosity, and digestibility. In countries where fermented foods, particularly porridges, are popular, there are, however, abundant anecdotal reports about the preference of the local people for fermented foods. In Africa, the sour, "biting" taste of fermented food is probably the characteristic most responsible for its popularity.

That flavour is a strong determinant in the desirability of fermented food is evident in the strict fermentation time employed for most products. Traditional processes of fermentation have evolved in such a way that food preparers are able to achieve the characteristic, acidic flavour that is most desirable to them. The desired flavour nearly always corresponds to a pH and titratable acidity of a very narrow range (usually a pH of 3.4-3.8). A pH value above or below this range produces an unacceptable product. An important controlling factor in reaching this level of acidity is the length of fermentation (usually 1-3 days).

A second characteristic of fermented foods that may account for their popularity is low viscosity. Although this property in itself is rarely acknowledged, local individuals will often claim that the fermented food is more nutritious and satisfying than its unfermented counterpart. The low viscosity achieved by the fermentation process may be a result of the presence of lactic or acetic acid, or of the breakdown of starch molecules, or both, depending on the product. Modification of the starch structure may occur through increased enzyme (e.g., amylase) activity, as has been shown in studies of preparations of weaning foods using flour from germinated cereals. Such modification results in lower water-binding in the gruels. For a given volume and consistency, this gives a product with a greater energy and nutrient density. Laboratory studies on fermented foods such as "ogi" and "uji" strongly suggest that in fermentation, particular microorganisms are responsible for the increased amylolytic activity: enzymes are secreted that convert storage nutrients in foods to those that can be readily utilized. In areas where the dietary staple is starchy and is made into gruels that have high dietary bulk and low nutrient content, low viscosity is of great importance in child feeding.

In some societies (e.g., Uganda and Rwanda), weaning foods such as "obusera" are prepared using a combination of germination and fermentation; this results in a porridge with low viscosity, high nutrient density, and the desirable sour taste. The mechanism(s) by which the fermentation process alone lowers the viscosity of porridge have not been thoroughly studied. It is likely that a biochemical process is involved similar to that occurring with the use, in cooking, of germinated cereals. The studies reviewed thus far have not, however, dealt thoroughly with the combined effect of microorganisms, fermentation, temperature, moisture content, acidity, etc., on the reduction of viscosity. Most fermented porridges are smooth in texture (i.e., void of hulls and fibre) and are reputedly rich in nutrients per unit volume.

A third characteristic of interest is the effect of the fermentation process on digestibility. Observation at the village level, and reports, largely unpublished, on sour porridge, suggest that fermentation does improve the digestibility of proteins and of other nutrients in cereals. It has been claimed in certain parts of Africa that the feeding of sick children with fermented porridges may improve appetite and recovery rates. These improved recovery rates would be attributable to a combination of increased energy intake and improved protein digestibility. In a study (using experimental animals) of pepsin digestibility of proteins in sorghum and other major cereals, it was shown that conversion of millet to the fermented baby food "nasha" (made in Sudan) raised the level of pepsin digestibility to that of wheat, maize, and rice. Conversion of sorghum to "nasha" also improved digestibility, although to a lesser extent (Mertz et al. 1984).

Although fermentation has an apparently favourable effect on protein digestibility, the degree to which this effect manifests itself varies from cereal to cereal; it may in fact depend on the previous nutritional state of the subject (Mertz et al. 1984). Further support of this effect of fermentation is provided by Hamad and Fields' (1979) study of protein digestibility in germinated and fermented cereals. These authors found that fermentation significantly improved the percentage relative nutritional value (RNV) and the levels of lysine available in millet, maize, oats, rice, and wheat. They also found that the increases in percentage RNV (i.e., protein quality) were comparable to those achieved by germination or by fermentation. Although research has been conducted on the effects of the germination process on digestibility, more comparative studies of the Hamad/Fields type are needed. With regard to nutrient digestibility, Rajalashmi and Ramakrishnan (1977) found that a combination of germination and fermentation is likely to be more advantageous than either used singly.

The effects of the fermentation process on antimicrobial properties of foods has been virtually neglected in the literature reviewed. Although there are numerous reports on the antimicrobial activities and growth requirements of various microorganisms, and on the growth of microorganisms during fermentation, the way in which the fermentation itself influences the antimicrobial characteristics of a fermented food is an area seemingly untouched. Of critical interest from the point of view of child feeding is the possible effect of fermentation on the survival and proliferation of diarrheal pathogens in foods.

Specific Uses of Fermented and Germinated Foods

One of the most important aspects of a study of fermented porridges is that of specific uses and effects in various cultures. Although fermented foods have been developed and are popular for their external characteristics and preservation value, in many societies they are undoubtedly used in connection with particular times of life, such as infancy, or with stresses, such as sickness. In improving or promoting fermented foods, researchers should take these special uses into consideration.

In a number of African countries, fermented porridges are frequently used as weaning foods for young children. Nigerian "ogi," Kenyan "uji," "bogobe" of Botswana, Sudanese "nasha," and "obusera" of Uganda and Rwanda are all used specifically (but not exclusively) to feed infants. It is claimed that sick babies may have their appetite stimulated by the sour taste of fermented porridge. Because of the smooth consistency and (in many cases) low viscosity of the fermented porridge, these porridges may have considerable nutritional advantage over unfermented porridge. This benefit may derive from an increase in the caloric content per unit volume consumed by the infant, and through increased consumption because of improved appetite. The fermentation process itself may improve the nutritional value of the raw materials used, as has been shown in studies of Tanzanian sorghum porridge, Sudanese "nasha," and other cereal porridges (Hamad and Fields 1979; Mosha and Svanberg 1983; Mertz et al. 1984). Rajalashmi and Ramakrishnan (1977) found that fermentation used with germination produces a porridge with a nutritional value equal to or greater than that of unfermented porridge.

Fermented foods are used for purposes other than infant feeding. Because of its refreshing taste and ease of transport, South African "mahewu" is very popular among industrial workers. Ghanaian "kenkey" and Ugandan "obusera" are similarly appreciated by agricultural workers. Because it is believed to increase milk output, Kenyan "uji" is traditionally given to lactating mothers. Fermented foods are used in many African countries for ceremonial and symboic purposes. Only a few of the many uses have been reported in the literature.

Traditional foods and beverages are still made, especially in rural areas; the practice is, however, declining. Although the preparation of these foods is not complex, it is often laborious and time consuming. As rural women migrate to the cities and enter the paid labour force, there may be less and less time available to them for the use of fermentation. Furthermore, as the influence of Western products and ideals of modernity become more pervasive in traditional societies, there may be commercial pressures against the use of fermented foods. In the urban areas, inexpensive and more convenient substitutes, such as tea and milk, may replace the fermented porridge. Unfortunately, this could have a detrimental effect in areas where the nutritional status of population groups is already marginal. It is, therefore, important that a more precise knowledge be gained of the nutritional benefits of fermented foods, and of their cultural acceptability. Researchers can then go on to improve and promote traditional fermented foods.

Nutritional Problems

A number of factors should be considered in connection with the foods described in the previous sections. High tannin varieties of sorghum that have the favoured property of resistance to birds are somewhat inhibitory to the amylolytic process of germination. The tannin content can be reduced by alkali treatment. Whole grain sorghum, without germination, has a relatively poor nitrogen content and is not easily digested by young children (MacLean et al. 1981). There is no information on the degree to which digestibility is affected by germination. Using an in vitro assay in which the effect of tannins is removed, Axtell et al. (1981) show that sorghum digestibility is satisfactory.

The question of cyanide toxicity from cereals and cassava needs consideration. There is a considerable difference in the cyanide content of different strains. Panaswik and Bills (1984) suggest that toxic levels are not reduced by germination. More recent work by Dada and Dendy (1987) show, however, that the cyanide content of sorghum (454 ppm cyanide as HCN) could be reduced by more than 96% during toasting at 180°C, and reduced by 70% during fermentation. The residual levels are considered safe. A process used at one time in Tanzania is described by Anderson (1944): the wet roots of cassava were stacked in a dark store until the moulds developed; changes in cyanide content were not, however, reported. Raymond et al. (1941) described the use, also in Tanzania, of cassava flour produced by pounding after fermentation; there is, however, little available information on the way in which household-level food technology affects cyanide content.

Wang and Fields (1978) review some of the nutritional advantages of home-fermented foods. These advantages are considerable; it will be essential, however, to consider potential problems of food toxicity, particularly if specific aspects of food technology are considered for promotion in any area. These problems of toxicity are most likely to centre around aflatoxins and cyanide.

Medicinal Uses

There is, evidently, widespread belief that these foods have health-promoting or curative value. Fermented foods are believed to act as galactagogues (promoting breast milk production), to protect children against malnutrition, and to be generally useful for the sick and the convalescent. In recent years, there has been increasing enthusiasm for the use of cereal-based oral rehydration therapy (ORT) for the management of diarrhea. The long chain carbohydrates are hydrolyzed into disaccharides by the various metabolic reactions during food preparation and by the pancreatic enzyme amylase. Disaccharides are then hydrolyzed by the enzymes of the brush border of the jejunal mucosa. The available glucose stimulates the absorption of sodium and water by the enterocytes. Cereal-based ORT has been produced using rice, maize, and sorghum. There is some suggestion that fermented or germinated food may be useful as home-based oral rehydration solutions; this has not, however, been evaluated. One consideration in any home-based solution is the possibility that excessive quantities of sugar may cause osmotic diarrhea. Nevertheless, the value of these solutions could be considerable, and careful testing is required.

Fermented Cereals and Diarrhea

Microbial Causes of Acute Diarrhea

During the last 10 years, laboratory methods for the detection of diarrheal pathogens have made it possible to identify the causes of the majority of cases of diarrhea among infants and young children (Sack 1973; Echeverria et al. 1975; Sack et al. 1975; Black et al. 1981; Gross 1983; Tomkins 1983b; Guerrant 1985). *Campylobacter* sp., *Shigella* sp., *Salmonella* sp., *Vibrio cholerae*, enterotoxigenic *E. coli* (ETEC), either stable (ST) toxin or labile (LT) toxin, enteropathogenic *E. coli* (EPEC), enteroinvasive *E. coli* (EIEC), *Aeromonas* sp. are the commonest bacteria causing diarrhea. *Giardia lamblia*, *Cryptosporidium*, *Capillaria*, and *Trichuris* are the commonest parasites causing diarrhea. *Rotavirus* and *Norwalk* Agent are the commonest viruses causing diarrhea. The range of clinical symptoms - from mild, watery diarrhea to severe dehydrating diarrhea or dysentery - depends on the type and infective dose of the organism. Tomkins (1986d) found that the clinical response is modified by the nutritional status of the host; this response tends to be more severe and more persistent in protein energy malnutrition (PEM).

Origin of Microbes

Several studies have shown that weaning food and water are important sources of enteropathogens (Rowland et al. 1978; Jiwa et al. 1981; Mathus and Reddy 1983; Lloyd-Evans et al. 1984). Contamination of porridges occurs at the initial stage of preparation, when contaminated water is added. The situation may be made worse by the transfer of microbes by those handling the food at subsequent stages of food preparation. Moreover, the high ambient temperature in many tropical communities, and the long periods of storage, may contribute to a high level of microbial contamination. The reheating of food may permit the development and release of food poisoning toxins by particular organisms. Flies are capable of transmitting a variety of diarrhea pathogens, especially *Shigella*.

Microbial Contamination of Fermented Foods

Of the considerable body of information available on microbial characteristics of fermented food, a part has been summarized in the previous section. There is, however, remarkably little information on one aspect of the subject: this is the prevalence of diarrheal pathogens in fermented foods that are prepared in homes whose sanitation, water supply, and domestic hygiene are poor. The opportunities for microbial contamination in fermented food would appear to be considerable. The storage of food during the fermentation process, at a temperature high enough to permit the microbial reactions to occur, obviously provides an ideal environment for the growth and development of a number of diarrheal pathogens.

On the other hand, there are certain features of the fermentation process that might inhibit the growth of diarrheal pathogens. Firstly, the high titratable acidity of fermented food (giving a pH of 3.5-4.0) might well inhibit certain bacteria. Secondly, the high levels of volatile fatty acids (butyric, propionic, and acetic acids) may be inhibitory: it is well established that Shigella sp. is inhibited in vitro by high levels of these compounds. Thirdly, early work suggested that there were certain chemicals produced during fermentation that acted as antimicrobials. Unfortunately, there is relatively little in the published literature to support these claims (Wang et al. 1969; Pulusani et al. 1979; Nyako et al. 1982). In the absence of detailed studies on the microbial quality of fermented cereals prepared in the home, it is not possible at present to say whether fermented foods are microbiologically safer than unfermented foods.

Use of Fermented Foods During Diarrhea

Many studies have shown the importance of diarrhea in precipitating growth-faltering, PEM, or individual nutrient deficiencies (Tomkins 1986a). The most important impact of diarrhea is on nutrient intake. Although intakes of breast milk are usually sustained even in severe diarrhea, the intakes of solid foods are often reduced by 30% or more. There are many cultural, clinical, and biochemical reasons for this reduced intake. The use of fermented food has been reported favourably in Tanzania (Mosha 1984) and in Indonesia. The inference from the various reports is that the lower viscosity, higher energy density, and preferred texture and taste of fermented food may be of considerable nutritional advantage; the published literature is, however, insufficient to allow us to conclude that the provision of fermented food to healthy or to sick children leads to a consumption of consistently greater amounts of energy and protein than would be consumed were the food unfermented.

Favourable comments on the use of fermented soybean ("tempeh") in Indonesia were received from subjects with diarrhea seen during and after the Second World War. More recently, a study of the management of children with persistent diarrhea and PEM showed a shortening of the duration of diarrhea among children receiving a "tempeh"-based oral rehydration formula. There is, however, no information on the effect of fermented cereals on intestinal function or on nutritional recovery in diarrhea.

Concern has been expressed that the use of fermented foods might interfere with the absorption of water and of electrolytes stimulated by the oral rehydration solutions given during acute diarrhea. There are no published data to confirm or to refute this possibility; the hydrolytic processes that occur during fermentation lead, however, to the production of dextrins, disaccharides, and monosaccharides. Thus, by analogy with "rice water" and "maize water" (substances of proven efficacy as oral rehydration agents), it might be predicted that fermented cereals would actually stimulate intestinal absorption of water and, if provided, of electrolytes. This would not necessarily be the case, however, if the sugar content of the fermented cereal were high. Studies of the fluxes of water across the intestine show that the optimum fluid absorption is achieved with a sugar concentration of 1.5-2.0%. If concentrations of more than 3% are used, there is an osmotic effect such that secretion is stimulated and fecal volumes increase. Careful but simple clinical studies are needed to resolve this question about the effect of fermented food on intestinal secretion.

A further question is whether fermented food is better absorbed than nonfermented food. Limited laboratory studies (Mosha 1984) showed increased bioavailability of a number of nutrients when fermented foods were given to experimental animals; no human studies have been reported. Nevertheless, if food is presented to the intestine in a fermented form, the bacterial hydrolysis and reduction of fibre content may well contribute to greater absorption.

Attitudes Toward the Use of Fermented Foods

Whatever the advantages or disadvantages of fermented foods, the use of these foods will be limited by existing beliefs as to their value. During a recent visit to a number of centres in Uganda, it became clear that there is considerable disagreement among mothers and health professionals (more so among the latter) about the value of fermented food. Many regard it as an excellent food for young children, both in health and in sickness; others have reservations about it. In the absence of any anthropological study on customs and beliefs, it seems premature to recommend unreservedly the use of fermented food.

Research topics There are several areas in which a basic lack of definitive information, rather than of anecdotal experience, restricts our ability to be confidently prescriptive in the promotion of household-level food technologies. The purpose of this section is to raise unanswered questions, to review that which is known of the status of research on those questions, and to suggest specific studies.

Can food intake be improved by household technologies? The usual premise is that the main problems of high viscosity, low-energy density, and limited bioavailability can be improved by household food technologies. Studies of food intake in Tanzania (reports from the Joint Nutrition Support Programme (JNSP) Project at Iringa) suggest that P.F. (such as "ugi-kimea," in which maize flour has been hydrolyzed by the addition of a germinated cereal) is associated with increased quantities of food eaten. This work requires confirmation: children given the normal maize, millet, or sorghum porridge should be carefully matched for age, nutrition, and health status with children who receive porridge that has had its consistency altered because of the amylolytic activities of added germinated cereal; careful measurements should then be made of the food intake of both groups. Such studies would, ideally, assess whether food intake is affected throughout the rest of the day: a high intake of a P.F.-type porridge during one meal might decrease the appetite in subsequent meals. Even limited studies of intakes at single meals would be valuable.

It is sometimes claimed that the fermentation process confers organoleptic advantages (such as sharper taste because of lowered pH, increased titratable acidity, and raised levels of volatile fatty acids). Here also, it will be important to compare the dietary intakes of children eating fermented food with those who are eating "normal," unfermented porridges.

A further consideration is the effect of the addition of juices, such as lime and tamarind, to porridges. It has been claimed that lime juice increases appetite. Whether this is true, and whether it acts by an organoleptic effect or by increased hydrolysis of food, or both, is not confirmed. Again, measurements of food intake will be useful.

All these studies are important; they will, however, be difficult to perform. They involve the weighing of food bowls before and after feeding, and the removal of small quantities of food for laboratory analysis. Such studies should be carried out with the minimum of social intrusion. The prerequisites are likely to include a confidence between the community and the investigator, and opportunities for checking on measurements "in the field" without seriously influencing the process of feeding. Possible sites for such studies should be examined carefully and critically.

An alternative approach would be to perform these measurements among children who are moderately malnourished (60-80% weight/age), and who are already in some form of nutrition program; in such cases, it wold be possible to measure food intake over considerable periods of time. Although such programs might include daycare centres, the administrative problems would be considerable. Furthermore, there are problems of monitoring food intake once the child has returned to his or her home for the rest of the day and the night. Alternatively, children might be studied who are in residential situations (nutrition rehabilitation centres or pediatric wards). The period of time between the loss of edema or initiation of catch-up growth (or both) and discharge from the nutrition rehabilitation unit might be an ideal time. As in all the foregoing studies, extreme care is needed in matching children for age, nutritional status, health status (especially regarding diarrhea), and type of feeding.

Can the type of food preparation affect the survival of diarrheal pathogens? The assumption from the literature is that many weaning foods are grossly contaminated by diarrheal pathogens, the most important being Shigella sp., Campylobacter sp., ETEC, EIEC, EPEC, Aeromonas sp., Bacillus cereus, Rotavirus, Giardia lamblia, and Entamoeba histolytica. The premise is that certain food-preparation processes provide a milieu that is inhibitory to these pathogens. Limited studies (verbal reports) in Kenya and Lesotho suggest that fermented porridges may inhibit certain bacteria. An important area for study is, however, the effect of the type of food preparation (especially fermentation and the addition of acid fruit juices) on the survival and multiplication of an inoculation of the foregoing pathogens in quantities that are capable of producing diarrheal disease. Attention should be given to the possible effects of inoculating such organisms at different stages of the food-preparation process. Does a diarrheal pathogen, for example, inoculated in the appropriate dose, survive better if inoculated at the first stage of the fermentation process than if it is added when the metabolic changes have already occurred? These studies require the services of skilled, experienced microbiologists with appropriate equipment and media for culture, identification, and quantification of the diarrheal pathogens already outlined. Such centres will need to be identified.

Studies of foods prepared under standardized conditions in the laboratory should be accompanied by measurements of the levels of contamination by diarrheal pathogens in food samples collected from homes. Because of the need to plate and incubate these samples as soon after collection as possible, these studies will have to be performed in close proximity to the laboratories. In practice, this will mean identifying families who prepare food using the technologies outlined in previous sections. Comparisons between "contamination levels" in the different food-preparation groups will have to allow for differing levels of personal hygiene, of sanitation, and of water supply, etc. A selection should be made of compliant families in rather poor environmental conditions - conditions that provide considerable opportunity for contamination by diarrheal pathogens; these families would be asked to prepare foods in different ways.

Epidemiological studies that carefully record diarrheal morbidity could be used to compare the efficacy of different methods of food preparation in preventing attacks of diarrhea. It is necessary, however, to control for the many variables that exist between families using different food technologies (even in the same environment); the studies will, therefore, require the skills of epidemiologists with considerable expertise in community-based morbidity studies.

What factors affect the choice of technology in food preparation? The premise is that mothers have a series of preferences and constraints that affect their choice of food-preparation method. Studies are needed that identify these preferences and constraints: without an understanding of them, attempts at a promotion of any particular food technology are likely to be unsuccessful.

Because of the variety of anecdotal reports, sometimes differing quite strikingly between regions within the same country, there is a need for region-specific studies. These may best be conducted by interviews with key informants (such as mature, experienced mothers with wide contacts in their local communities) and with other appropriately selected individuals. The interviews should concentrate on beliefs concerning the suitability of the food technologies for the feeding of children of different ages and health statuses; inquiries should also be made as to whether there are certain food technologies that are considered "protective" in terms of food hygiene or of nutritional status. The inquiries should also concentrate on factors affecting the ability of a mother to use a particular technology (such as the seasonal availability of food, the time required, or the financial implications). Most of these studies should be cross-sectional: fieldworkers should be trained and supervised by a staff that has considerable experience in obtaining accurate, reliable information by interviews "in the field." The methods used are likely to include combinations of carefully conducted interactive interviews and formal questions. It would be valuable to have evaluations of existing projects on food-technology promotion.

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FERMENTED "UJI" AS A NUTRITIONALLY SOUND WEANING FOOD

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Abstract *Household-level food technologies involve preparation methods that can influence, positively or negatively, the nutritional quality of foods. Fermentation is a simple, low-cost technology that requires relatively little energy; this technology can be applied in rural areas to produce foods that are both nutritionally sound and safe. Fermentation is known to detoxify natural food antinutrient substances, to enrich foods with vital nutrients, and to render food more digestible. Fermented "uji" can be prepared from cassava, sorghum, millet, or maize flours, all of which are available in rural households. This food is said to stimulate milk production in lactating mothers. Although fermentation tends to increase levels of riboflavin and tryptophan in "uji," the process has no effect on niacin. Phytate is apparently hydrolyzed by fermentation, but amylolysis appears limited, thus having little effect on the bulkiness of the food. Some preliminary results show that the "uji" fermentation tends to eliminate coliforms. More investigations are, however, necessary to assess the effect of "uji" fermentation on the diarrhea-causing organisms that frequently contaminate weaning foods.*

In the rural areas of developing countries, household-level food technologies are generally characterized by their simplicity, their low energy requirement, and their modest cost. These factors are important in areas of poverty and lack of essential facilities such as clean water and fuel. Moreover, these technologies have evolved over generations: experience has taught us to reject those techniques that are not safe and beneficial. Household-level food technologies make the best use of the locally, and therefore most abundantly, available raw materials. Despite these advantages, however, there is no doubt that when an innovative food or food preparation method is introduced without proper education and appropriate resources, problems are likely to occur: those weaning foods introduced by the developed world into the rural areas of developing countries have had a negative effect on nutritional status.

Porridges, whether fermented or not, have been used for a long time as weaning foods in Africa. A porridge such as "uji" can be simply prepared from raw materials ranging from root crop flours, such as cassava, to cereal flours, such as maize, sorghum, and millet

(Mbugua et al. 1983). Such gruels contain nutrients (carbohydrates and minerals) important to a growing child; supplemented with a good source of protein, such as breast milk, these gruels have for generations been used successfully as weaning foods in different parts of Africa.

Food-Processing Methods

Household food technologies are generally simple. They should be low in cost, relatively unsophisticated, and, most importantly, low in energy consumption. Table 1 shows the classification of various food preparation methods that are likely to be encountered at the household level.

Food preparation by means of biological modification in general means the use of that method which is least energy-intensive and lowest in cost. Such a method could involve simply placing the food in a container and storing it for some period at ambient temperature. During this period, spontaneous, natural biochemical changes set in through modification by microorganisms or enzymes. It is by sheer good luck, however, that some of these biochemical changes have produced certain foods that are nutritionally sound and safe for consumption. In most plant food materials, lactic acid fermentation tends to establish itself as long as water activity and redox potential are appropriate in the plant food system. This has proved to be extremely useful to humans and animals: the sour taste is highly acceptable, and the low pH inappropriate for the growth of pathogens.

The example of "uji" preparation by fermentation illustrates the simplicity with which the fermentation process can be applied. Slurries of flour in water are prepared and left to ferment spontaneously for some days. The metabolic associative growth of the microorganisms leads to a predominance of lactobacilli, which are tolerant to high acidity: the nonacid-tolerant organisms are sequentially eliminated (Mbugua et al. 1984). The spontaneous lactic fermentation of "uji" is attributed mainly to Lactobacillus plantarum, some coliforms, heterofermentative Lacto bacilli, such as Lactobacillus fermenti, Lactobacillus cellobiosus, and pediococci (Mbugua et al. 1984). In food preparation, the 2 major objectives are usually safety and organoleptic acceptability; the nutritional implications of food preparation methods are usually of a lower priority, or are not considered at all.

Nutritional Implications for Household Food Technologies

A nutritionally sound food is characterized by factors of nutritional quality, and should be devoid of those factors creating nutritional stress. Factors of nutritional quality include the nutrients present in the food, and the antinutritive elements, the level of which should be zero. Nutritional stress factors are those that tend to increase nutritional requirements: these factors include deficiencies in diet, imbalance among nutrients, and the presence of deleterious substances such as chemicals and microorganisms that can cause diarrhea and other illnesses. Table 2 shows a list of nutritional stress factors and their properties.

Table 1. **Organization of food preparation methods.**

Group/type of operation	Unit operation
Separation	
Physical	Extraction, sieving
Mechanical	Cleaning, grinding, dehulling, filtration, winnowing
Chemical	Hydrolysis
Biological	Fermentation, enzymatic modification
Preservation	
Physical	Dewatering, temperature modification, packaging
Mechanical	Washing, soaking
Chemical	Smoking, curing, salting, pH changes
Biological	Fermentation
Preparation	
Physical	Cooking, baking, frying
Mechanical	Mixing, mushing
Chemical	Aging
Biological	Sprouting, malting

The various food preparation methods at the household and industrial levels can influence nutritional stress factors to the advantage and the disadvantage of consumers. Although preparations involving dehulling and milling lead to a decrease of tannins in dry beans and to the removal of phytates, this has its advantages; on the other hand, some protein, some minerals (such as iron, copper, and zinc), and some vitamins are lost. Soaking and other extraction methods are known to reduce thioglycosides and cyanogenic glucosides. Such has been the case in Nigerian "gari" preparation where, unfortunately, large quantities of Vitamin C are lost; thiamine, riboflavin, and niacin are also lost during the steeping processes of "ogi" preparation (Akinrele 1970). Alkali treatment of sorghum with wood ash in Burundi is said to reduce substantially the levels of tannins (Price et al. 1979); this treatment is likely, however, to reduce protein quality by forming artifactual amino acids.

The fermentation process is known to be extremely effective in eliminating a number of nutritional stress factors. In "uji" fermentation, hydrolysis of phytate is reported (Mbugua et al. 1983). Because of the subsequent acidification, however, amylolysis during "uji" fermentation is extremely limited (Mbugua et al. 1983); a reduction in bulk for infant feeding cannot, therefore, be achieved in this way. The natural lactic acid fermentation is also said to detoxify sunflower meal by reducing the chlorogenic acid (Knorr 1987). The lactic acid-producing bacteria and other organisms with alpha-galactosidase enzymes are important in reducing oligosaccharides, such as raffinose, stachyose, and verbascose, that cause flatulence and diarrhea in humans. Those with beta-galactosidase activity can be useful in hydrolyzing lactose in milk products, thus enabling people who are lactose-intolerant to consume milk-based products.

Table 2. Nutritional stress factors in some common food materials.

Stress factor	Chemical nature	Occurrence	Action	Dietary effect
Phytates	Organic acid	Cereals, legumes	Chelates metals	Decreases mineral availability
Oxatates	Organic acid	Spinach, amaranth	Chelates cations	Decreases Ca and Fe availability
Gossypols	Polyphenol	Cotton seed	Chelates metals Reactive	Anemia Potential poisoning
Tannins	Polyphenol	Beans, sorghum	Binds proteins	Protein made insoluble Enzyme inactivated Decreases Fe and B_{12} availability
Avidin	Protein	Egg white	Binds biotin	Biotin made available
Trypsin inhibitors	Protein	Legumes, cereals	Inhibits proteolysis	Decreases protein availability
Solanine	Alkaloid	Potato	Inhibits choline esterase	Gastrointestinal or neurological disorders Potential poisoning
Linamarin	Cyanogenic glycoside	Cassava	Releases cyanide	Potential poisoning
Thiaminases	Protein	Fish	Destroys thiamine	Possible thiamine deficiency
Goitrogen	Glucosinolate	Rapeseed, cabbage	Goitrogenic	Decreases iodine intake

It has been noted that sunflower meal can be detoxified by lactic acid fermentation. Detoxification of gossypol by Diploida fungus has been observed in cottonseed meal (Knorr 1987). Cassava is detoxified by use of corynebacterium organisms (Akinrele 1970). Fermented peanuts with *Aspergillus oryzae* are said to contain no aflatoxins, and Rhizopus *moulds are even said* to degrade aflatoxin (Knorr 1987). The high intake of fermented milk has been reported to result in decreased cholesteremia (Spoerry 1974). Even the omnivorous rats fed with *Lactobacillus acidophilus* organisms produced decreased activities of *beta-glucuronidase, nitro*reductase, and azoreductase, the bacterial enzymes in the gut believed to convert procarcinogens to proximal carcinogens (Knorr 1987). The bacterial organisms are said to produce similar effects in humans.

Because it is believed to stimulate milk production, fermented "uji" is sometimes prescribed for lactating mothers who are short of milk. This belief needs to be investigated; it is known, however, that lactic acid, a major organic acid in fermented "uji," stimulates the absorption of calcium, a major mineral in milk formation. The fermentation of "uji" has been shown to be efficient in inhibiting and eliminating coliforms (Mbugua et al. 1984). This would imply that the process can be effective in eliminating diarrhea-causing organisms, particularly those from the enterobacteriaceae group; also indicated is the potential for "uji" as a weaning food, especially under relatively unsanitary conditions. More work, however, needs to be done in this area. Studies with diarrhea-causing organisms, such as salmonella, staphylococci, and enteropathogenic *Escherichia coli* have shown that they can be inhibited in milk by *different lactic a*cid-producing bacteria (Minor and Marth 1972; Park and Marth 1972; and Frank and Marth 1977). Further studies with "uji" have shown that during fermentation, levels of riboflavin and tryptophan increase significantly (Mbugua 1986). Increases in lysine, leucine, isoleucine, methionine, and relative nutritive value have been reported in various fermented cereals (Hamad and Fields 1979; Kazanas and Fields 1981).

Conclusions

The advantages of fermented foods as described in the literature far outweigh the disadvantages. Examining the nutritional benefits, the convenience, the low cost, and the safety of fermented foods, it appears that such foods could be extremely useful in weaning. It is not clear, however, why in many societies these foods have not been widely used; there is a need for research and for promotion, especially in those areas whose local conditions call for the particular advantages provided by fermentation.

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FERMENTATION OF MAIZE-BASED "MAHEWU"

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Abstract *Studies were made on the production of lactic acid and pH changes during "mahewu" fermentation. The following parameters were found to affect these changes: varying quantities of sorghum malt, incubation temperature, ingredient type added to the porridge, solids content of the porridge, and cooking time. The quantity of sorghum malt added to cooked porridge significantly ($P \leq 0.01$) influenced the amount of lactic acid produced. Incubation of "mahewu" (12% solids) at 45°C for 16 h produced the most acceptable product. The addition of wheat bran to the cooked porridge before fermentation resulted in the highest amount of lactic acid (0.450%) produced. The addition, however, of rapoko/sorghum malt produced the most acceptable "mahewu," with 0.575% lactic acid. "Mahewu" with 14% solids content was judged the most acceptable. The amount of lactic acid produced was not significantly affected by cooking time.*

"Mahewu" is a nonalcoholic beverage popular among the indigenous people of southern Africa. The consumption of "mahewu" is highest among farmers, school children, and junior members of staff of mining companies and industrial firms. Because of the improved nutritional value of the fermented product, nongovernmental organizations (NGOs) in Zimbabwe, such as the Red Cross and Christian Care, have used "mahewu" in supplementary feeding programs.

Even though some degree of success has been reported in the commercial production of "mahewu" in South Africa (van Noort and Spence 1976), the basic knowledge of the principles involved in "mahewu" fermentation cannot support present industrial enthusiasm. Commercial "mahewu" production in Zimbabwe has met with limited success. Two companies - Nutresco (Pvt) Ltd and Food and Industrial (Pvt) Ltd - are currently involved in large-scale production of "mahewu". Nutresco's "mahewu," made from precooked maize meal, sorghum flour, and barley malt enriched with minerals, vitamins, and fortified with soy protein, is claimed to be high in protein (15-19%) and in energy (330-402 kcal/100 g).

Food and Industrial (Pvt) Ltd produces two forms of "mahewu" - standard and instant. Standard "mahewu" is made from precooked maize meal, sorghum malt, sodium benzoate (as a preservative), and saccharin. Instant "mahewu" powder is made from precooked maize meal, milled roasted maize grains, lactic acid (to impart the characteristic "mahewu" flavour), brown sugar, and saccharin. Both mixtures are enriched with minerals and vitamins and are fortified with full fat and defatted soy meal. The continued use of saccharin is, however, disturbing: there is concern over evidence from animal experiments, linking saccharin to certain carcinomas (Newell 1981; Waddell and Lachance 1981; Jensen 1985; Schoenig and Anderson 1985). The method of production and the ingredients used vary from place to place.

Different methods of producing "mahewu" have been described by different workers (Van der Merwe et al. 1965; van Noort and Spence 1976; Steinkraus 1983). Steinkraus (1983) notes that wheat flour provides the inoculum and is the source of growth for the spontaneous fermentation. The fermentation of maize meal to produce "mahewu" is a spontaneous process in which the natural flora of sorghum malt or wheat flour carry out the fermentation. The traditional souring process is not ideal for large-scale industrial production. First, the initial inoculum of the desirable lactic acid producing bacteria is very low, resulting in low acid production in the early phase of fermentation - an extended competitive phase, during which aerobic microorganisms survive and produce undesirable end products. Second, uncontrolled ambient fermentation temperatures favour the growth of undesirable microorganisms and can result in a secondary fermentation that produces acetic acid, butyric acid, or both - acids that detrimentally affect the taste of the product.

Schweigart and de Wit (1960) demonstrated that the fermentation process of maize porridge could be reduced from 36 h to 3 h using a starter of Lactobacillus bulgaricus and L. delbrueckii. This enhancement of the fermentation process has been used in the preparation of "ogi" and "ting" (Banigo et al. 1974; Mpuchane 1985).

Fermentation has been proposed by several investigators as a way of improving the nutritional quality of cereals (Hamad 1978; Hamad and Fields 1979; Kazanas and Fields 1981). Cameron and Hofvander (1971) reported an increase in the riboflavin and niacin content of fermented maize. Kazanas and Fields (1981) observed that natural lactic fermentation of ground grain sorghum increased significantly the availability of the following: lysine, leucine, isoleucine, methionine, niacin, thiamin, and riboflavin. As well as improving the nutritional value of foods, lactic acid producing bacteria are also reported to produce antimicrobial agents that inhibit the growth of undesirable microorganisms (Shahani et al. 1976, 1977). To gain a better understanding of "mahewu" fermentation, experiments were therefore designed to study the effects of the following parameters: variations in the quantity of sorghum malt, optimum incubation temperature, type of ingredient added to the porridge, solids content of the porridge, and cooking time, with respect to the production of lactic acid and pH change.

Materials and Methods

Tap water (500 mL) was added to a mixture of 30 g of maize meal and 30 g of sorghum malt. The resultant broth was boiled for 10 min. The porridge (12% solids) was cooled rapidly (by immersing pot in cold tap water) to ambient temperature (average 20°C). The 500 mL of porridge was then poured into fermentation jars. An appropriate quantity of sorghum malt (0-60% w/w) was added to each jar and the contents were thoroughly mixed by shaking; this mixture was then incubated at 25°C for 16 h, after which the percentage lactic acid and pH were determined.

Sorghum malt (30 g) was added to eight jars, each containing 500 mL of porridge (12% solids). The contents were thoroughly mixed by shaking and a sample taken of each and incubated at 20, 25, 30, 35, 40, 45, or 50°C for 16 h. To the porridge, 30 g of one of the following ingredients (National Foods (Pvt) Ltd, Harare) was added: wholemeal wheat flour, plain wheat flour, sorghum malt, barley malt, rapoko/sorghum malt (1/3 rapoko, 2/3 sorghum malt), maize meal (No. 1 Roller meal), and wheat bran (Red Seal). A control batch of porridge was made, to which no ingredient was added after cooking. A sample of each of the above treatments was incubated at 25°C for 16 h. Porridge samples of 500 mL were prepared as discussed but containing 8, 10, 12, 14, 16, and 20% solids. The samples were incubated at 25°C for 16 h.

Seven porridge samples (12% solids) of 500 mL were prepared and heated to boiling for different periods of time. The porridge samples were boiled for 0, 10, 20, 30, 40, or 50 min. After cooling the porridge to ambient temperature, 30 g of sorghum malt was added to each and the contents were thoroughly mixed. The resulting broth was then incubated at 25°C for 16 h.

To a weighed sample of "mahewu" filtrate in a 250-mL flask, three drops of phenolphthalein indicator were added. The mixture was titrated against 0.1 N NaOH.

$$\%\ \text{lactic acid} = \frac{N \times V \times \text{milliequivalent (ME) of lactic acid} \times 100}{\text{weight of sample (g)}}$$

where N is the normality of NaOH, V is the volume of NaOH used (to end point), and ME is the $\frac{\text{molecular weight lactic acid}}{1000} = 0.09008$. The pH of "mahewu" was measured using a digital pH meter (PTI-15). A panel of four staff members, untrained but with experience of traditional foods, evaluated the "mahewu" using a simple preference test.

Results and Discussion

Fermentation of "mahewu" is dominated by lactic acid producing bacteria that convert sugars derived from the starch into mainly lactic acid, depending on the predominant microorganism. The sourness caused by this lactic acid has become a major organoleptic property in the traditional evaluation of "mahewu."

Effect of Adding Sorghum Malt to Porridge

The quantity of sorghum malt added to porridge significantly ($P \leq 0.01$) increased the amount of lactic acid produced (Table 1). Without any sorghum malt added to the porridge, only 0.20% lactic acid was produced after fermentation; 0.52% lactic acid was produced, however, when 30 g (5.49% w/w) of sorghum malt was added. This latter product had the most acceptable flavour. The addition of 60 g (10.70% w/w) of malt produced a product with 0.65% lactic acid, which was too "tangy" and of poorer body.

Because sorghum malt provides the initial inoculum, the higher the quantity of malt used, the greater the number of lactic acid producing bacteria present. Moreover, malted sorghum serves as a source of alpha- and beta-amylase enzymes for the saccharification of starch (Kneen 1944). These enzymes convert amylopectin and amylose (the constituent polysaccharides of starch) to dextrins and maltose, which are readily fermented by the lactic acid producing bacteria to lactic acid and other end products responsible for the final taste and flavour of the "mahewu." Steinkraus (1983) reported similar findings when wheat flour was used for spontaneous fermentation.

Effect of Incubation Temperature

The incubation temperature significantly affects the amount of lactic acid produced by the natural microflora in traditionally fermented "mahewu" (Table 2). Incubation of "mahewu" at 35, 40, and 45°C produced 0.55, 0.52, and 0.50% lactic acid, respectively. Although all three products were judged acceptable, the product incubated at 45°C was preferred. Increasing the incubation temperature to 50°C resulted in a decrease in the amount of lactic acid. This is because the optimum temperature of the natural microflora had been exceeded, resulting in loss of activity and

Table 1. The effect of varying sorghum malt quantity on lactic acid production by the natural microflora in traditionally fermented "mahewu."

	Sorghum malt treatment (g)						
	0	10	20	30	40	50	60
Lactic acid after 16 h incubation (%)	0.20	0.36	0.37	0.52	0.51	0.58	0.65[a]
pH after 16 h incubation	4.24	3.57	3.52	3.59	3.64	3.67	3.60

[a] Statistically significant at $P \leq 0.01$.

Table 2. The effect of incubation temperature on lactic acid production by the natural microflora in traditionally fermented "mahewu."

	Temperature (°C)						
	20	25	30	35	40	45	50
Lactic acid after 16 h incubation (%)	0.32	0.47	0.48	0.55	0.52	0.50	0.46
pH after 16 h incubation	4.07	3.55	3.41	3.18	3.23	3.29	3.39

possible inhibition of some of the lactic acid producing bacteria. Schweigart and de Wit (1960) observed an optimum temperature range of 30-35°C for South African "mahewu" incubated for 36 h. "Mahewu" incubated at 45°C has been found to be the preferred product: the optimum temperature for lactic acid producing bacteria is 45-50°C; at these temperatures, the growth of acetic and butyric acid producing bacteria is suppressed, resulting in a product of good quality.

Effect of Ingredient Type Added to Porridge

The amount of lactic acid produced and the pH of traditionally fermented "mahewu" varied with the ingredient added to the cooked porridge (Table 3). The addition of wheat bran to porridge produced the highest amount (0.450%) of lactic acid after fermentation, followed by barley malt (0.374%), rapoko/sorghum malt (0.373%), sorghum malt (0.350%), and maize meal (0.249%). Although Schweigart and de Wit (1960) found that the addition of wheat flour acted as a stimulant for bacterial growth, in the present study the addition of wheat flour and wholemeal flour did not exhibit any stimulatory properties on the growth of the desirable lactic bacteria.

Conditioning wheat before milling with different plants helps inactivate amylases and other enzymes that convert starch into soluble sugars. "Mahewu" prepared with rapoko/sorghum malt was the most acceptable, followed by products to which sorghum malt, maize meal, and barley malt were added.

Solids Content of Porridge

There was a general but nonlinear increase in percentage lactic acid produced with increasing solids content (Table 4). The differences were not significant between percentages of lactic acid produced

Table 3. The effect of ingredient type on lactic acid production by the natural microflora in traditionally fermented "mahewu."

Ingredient type	Lactic acid after 16 h incubation (%)	Lactic acid before incubation (%)	Lactic acid produced (%)	pH before incubation	pH after 16 h incubation
Wholemeal flour	0.251	0.123	0.128	5.56	4.36
Plain wheat flour	0.297	0.155	0.142	5.55	3.70
Sorghum malt	0.560	0.210	0.350	5.40	3.44
Barley malt	0.542	0.168	0.374	5.52	3.61
Rapoko/sorghum malt	0.575	0.202	0.373	5.48	3.57
Maize meal	0.411	0.162	0.249	5.54	3.65
Wheat bran	0.660	0.210	0.450	5.77	3.84
No additive	0.294	0.077	0.217	5.40	4.13

Table 4. The effect of solids content of porridge on lactic acid production by the natural microflora in traditionally fermented "mahewu."

	Solids content of porridge (%)					
	8	10	12	14	16	20
Lactic acid after 16 h incubation (%)	0.374	0.429	0.418	0.445	0.548	0.660
pH	3.37	3.46	3.49	3.47	3.68	3.68

with solids contents of 10, 12, and 14% (0.429, 0.418, and 0.445%, respectively). There was an increase in the percentage of lactic acid (0.548 to 0.660%) for samples with 16 and 20% solids content. The increased solids (maize meal and sorghum malt) increased the source of sugars for conversion to lactic acid and also the initial population of lactic acid producing bacteria. "Mahewu" made from porridge containing 14% was judged most acceptable.

Cooking Time of Porridge

The cooking time of porridge has not been shown to bear any relationship to the amount of lactic acid produced during spontaneous fermentation of "mahewu." Boiling (cooking) porridge is not, therefore, necessary for the production of lactic acid during fermentation. The presence of the appropriate natural microflora and enzymes appears to be enough to cause fermentation. The organoleptic properties of the uncooked broth (slurry) were, however, unacceptable to the taste panel. This demonstrates that the amount of lactic acid in the final product is not the only factor that determines the quality and acceptability of "mahewu."

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CONSUMPTION OF WEANING FOODS FROM FERMENTED CEREALS IN KWARA STATE, NIGERIA

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Abstract *To define infant and child feeding practices in relation to diarrhea, research was undertaken in Kwara State, southwestern Nigeria; this research included community-based, ethnographic studies, food frequency questionnaires, and quantitative observations of dietary intake and of child feeding techniques. The survey questionnaire indicated that the initiation of breastfeeding was almost universal, with a median duration of about 18-24 months. Fermented cereal paps, served in liquid form, were consumed by more than 90% of children over 5 months of age. Information is given as to composition of the raw fermented cereal paste and that of the prepared cereal paps, as well as the amounts served and consumed. The consumption of dietary energy did not vary according to the stage of illness. Cereal paps provided an average of 20-26 kcal/kg per day; this represented, for infants 5-11 months and for children 12-26 months, 23 and 32% of total energy intake, respectively. The energy density of cereal paps was greater when the paps were fortified with sugar or other ingredients; children who received fewer servings per day ate porridges with higher energy concentrations. There was a positive, statistically significant relationship between the energy density of an individual serving and the total energy provided by the serving. Survey research and behavioural observations indicated that hand-feeding was the most common feeding technique for children less than 24 months. "Forced" hand-feeding tended to be more common when the child was suffering from diarrhea.*

The Dietary Management of Diarrhea (DMD) Project has been established for the development and implementation of strategies to improve the nutritional management of childhood diarrheal diseases.

The project has been implemented in the context of the national diarrheal disease control programs in Nigeria and Peru. The rationale for this program derives from the numerous epidemiological observations that demonstrate a significant negative relationship between diarrheal disease prevalence and children's somatic growth (Martorell et al. 1975; Rowland et al. 1977; Black et al. 1984); in addition, recent clinical studies that suggest that continued feeding of children during diarrhea with selected food products yields improved clinical or nutritional outcomes (Khin-Maung et al. 1985; Santosham et al. 1985; Brown et al. 1988). It is assumed that promotion of improved nutritional therapy will reduce or eliminate the negative nutritional consequences of diarrhea and will produce an overall improvement in the nutritional status of the population.

The specific objectives of the DMD project are to identify readily available, culturally appropriate, economical, and clinically efficacious feeding regimens of high nutritional quality for use during and after diarrhea. The project's first phase, which is now nearing completion, has been devoted in part to the description of current feeding practices for infants and young children and to the identification of suitable local foods for the management of diarrhea. This information is being used to formulate mixed diets that will be subjected to clinical trials during phase 2 of the project. Finally, in phase 3, the optimal diets will be promoted for wide-scale use during a pilot health education/communications campaign in the Yoruba-speaking areas of Kwara State.

The first phase of research has included ethnographic studies, a sample survey, seasonal market surveys, and quantitative studies of dietary intake during and after diarrhea. This paper will review some of the preliminary results from these studies in Nigeria - studies that highlight the importance of fermented cereal products as weaning foods in the southwestern part of the country. Following a description of the study site, information will be presented on the age of introduction of specific weaning foods, the methods of preparation of fermented cereal products, the macronutrient content of these products, the amounts consumed, and the feeding techniques employed.

Study Site

The studies are based in the Yoruba-speaking local government areas of Kwara State, which is located at the northern extreme of Yorubaland in the savanna belt of southwestern Nigeria. The population of Kwara State is predominantly Muslim, although the area is transitional between the majority Christian population of southern Nigeria and the majority Islamic population of northern Nigeria.

The quantitative studies of dietary intake and the behavioural observations of feeding practices were conducted in the villages of Laduba and Ago, which are located about 20 km south of Ilorin, the state capital. The total population of the villages is roughly 4500 individuals, including those who have migrated to an urban area but still consider the villages as home. About 2150 individuals actually reside in the villages on a regular basis, including some 250 children less than 5 years of age. Of these, an average of about 100 children between 6 and 36 months of age have participated in the surveillance activities and in the dietary and behavioural studies.

(The number of children under surveillance varies from month to month.)

Introduction of Weaning Foods

A representative population-based survey of child feeding and diarrhea-treatment practices was undertaken in the Yoruba-speaking areas of Kwara State during the first half of 1987 using a cluster sampling technique. Mothers of about 2600 children less than 3 years of age were interviewed. Thirty representative cluster sites were randomly selected. Preliminary results are available from 18 of these 30 clusters, 9 each from rural and urban areas. Because less than one-third of the inhabitants of Kwara State reside in urban areas, these areas are overrepresented by the clusters. Results will, therefore, be presented separately for rural and urban sites.

Breastfeeding was almost universally practiced during the initial months of life (Table 1). In rural and urban areas, 69 and 29%, respectively, of children between 18 and 23 months were still breastfeeding.

A list of all foods used to feed infants and small children was prepared from the results of the initial ethnographic studies (Bentley et al. 1988). During the sample survey, the children's caretakers were asked which of these foods had been consumed by the index child during the previous 7 days. The results of these interviews by age group and residence are shown in Table 2. During the first 6 months of life, liquid cereal paps and commercially prepared infant formulas (or "fudu" from the English word "food") were the major foods that were received. Although infants from urban areas tended to receive infant formulas more frequently than those from rural areas, the proportions receiving paps were similar.

During the second 6 months of life, almost all children received liquid cereal paps, whereas the proportion who received infant formulas declined. Although some solid foods began to appear in the dietary frequency histories, most of these foods included in the questionnaire were consumed by less than half the children. In general, the urban children tended to consume each of the solid foods

Table 1. Number (%) of children breastfeeding by age group and residence.

	Urban			Rural		
Age group (months)	**Number of children**	**Number breast-feeding**	**%**	**Number of children**	**Number breast-feeding**	**%**
0-5	200	198	99.0	199	194	97.5
6-11	160	156	97.5	197	195	99.0
12-17	165	130	78.8	137	122	89.1
18-23	106	31	29.2	101	70	69.3
24-35	161	6	3.7	157	24	15.3

Table 2. Percentage of children consuming specific foods at least once weekly by age group and residence.

Food	Residence	Age group (months)				
		0-5	6-11	12-17	18-23	24-35
Edko mimu (liquid pap)	Urban	34	94	96	94	91
	Rural	39	97	99	95	96
Eko jije (solid pap)	Urban	1	22	50	62	74
	Rural	1	17	54	71	80
Ewa funfun (cowpea)	Urban	5	58	86	93	98
	Rural	3	42	77	87	91
Rice	Urban	1	41	85	94	96
	Rural	2	25	73	84	91
Amala (yam)	Urban	1	27	70	89	96
	Rural	2	23	59	75	92
Bread	Urban	1	27	65	75	88
	Rural	2	19	52	80	81
Epa (groundnut)	Urban	1	17	50	69	79
	Rural	1	11	37	62	70
Eba (cassava)	Urban	1	7	28	54	68
	Rural	0	3	16	42	59
Soybean	Urban	0	5	7	12	18
	Rural	1	6	12	12	18
Condensed milk	Urban	4	19	40	55	59
	Rural	3	19	36	39	42
Infant formula	Urban	56	26	11	7	7
	Rural	32	11	4	2	2

more frequently than did the rural children. During the 2nd year of life, liquid paps remained the most commonly consumed foods. In addition, the majority of the children began to receive solidified (gelatinized) paps and other solid foods.

During additional ethnographic studies, mothers were also asked their opinion regarding the appropriate age to introduce solid foods, including the commonly consumed "amala" (boiled yam or cassava flour), cassava, and cowpeas (Mebrahtu 1987; Schumann, D., Bentley, M.E., Adegbola, C. Diarrheal classification and management among the Yoruba of Kware State, Nigeria. Submitted for publication). In the rural areas, the majority of mothers felt that children should not receive these solid foods until after their first birthday. These mothers felt that an earlier introduction of solid foods could result in development problems for the child: a child fed yam too early could, for example, become "wiwo," or "heavy" (an undesirable state), in contrast to "fuye," or "light" - a state that is considered healthy.

A "heavy" baby is not able to walk or move around properly, is "inactive," and is "heavy to pick up." A "fuye" baby is one who is "active," "light to pick up," and does not "trouble the mother." To achieve the desired state of "fuye," the child should consume "ogi" (fermented cereal, usually prepared as a pap) and breast milk, and should remain free from sickness. These beliefs about infant feeding and weaning may have important implications for the improvement of nutrient consumption.[1]

Preparation of Fermented Cereals and Cereal Paps

Because of the frequency with which cereal paps were consumed by infants and young children, special studies were undertaken to define the composition of the fermented cereal paste ("ogi") from which the pap is prepared, as well as the "ogi" content of the prepared pap and the amounts of pap served and consumed. In Nigeria, fermented cereal products are prepared from maize, sorghum (guinea corn), and millet. In the transitional zone of Kwara State, both maize and sorghum are commonly used; maize is used more commonly in the south and sorghum and millet are more popular in the north. In all cases, the dried whole grain is soaked in water at ambient temperature for 1-3 days. The fermented product is then wet-milled to a thick slurry that is sieved through a cloth with additional water to separate the "chaff" from the "ogi" or fermented cereal paste.

In the study villages, home-prepared "ogi" is commonly made from sorghum, whereas "ogis" that are produced for sale are generally prepared from maize. In the home, the "ogi" is left in a container under fresh water, which must be changed daily to prevent spoilage. The "ogis" can be stored in the home for 3-4 days. Before consumption, a portion of the stored "ogi" paste is diluted in additional water and cooked by boiling to prepare the cereal pap, or "eko"; this may be served to the whole family or to the children only. Adults often consume pap for breakfast, whereas children (especially infants) continue to receive the pap throughout the day. Sugar, milk, or other ingredients may occasionally be added to the prepared pap.

Composition of "Ogi"

Several studies of the nutrient content of maize "ogis" have been published previously (Akinrele and Bassir 1967; Oke 1967; Banigo and Muller 1972; Ojofeitimi et al. 1984). A summary of these earlier results indicates that the moisture content of "ogi" is extremely variable (Table 3). When the proximate composition is expressed per unit dry weight, however, the results are more constant. The energy content of "ogi" is particularly stable, ranging between 405 and

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[1] Ethnographic fieldwork to further delineate the folk taxonomy of a "healthy" or "unhealthy" baby is underway in the intervention area. The concept of "heaviness" appears to be related to the clinical symptoms of kwashiorkor, particularly edema and lethargy.

420 kcal/100 g dry weight; the protein and fat contents appeared to be more variable, possibly in relation to the degree of sieving that was performed.

Five samples of "ogi" were obtained in the study villages of Laduba and Ago; information from these samples was compared with that previously published. The three samples of maize "ogi" (Table 4) were similar in nutrient content to those analyzed earlier (Table 3). Again, both the moisture content of the wet "ogi" and the protein content per unit dry weight of "ogi" were more variable than was the energy concentration of the dry product. The sorghum "ogis," prepared exclusively for home use, had greater water contents and higher amounts of protein (N x 6.25) per unit dry weight than had the maize "ogis" (Table 4). Because of the variability that was observed, it was decided that an aliquot of each of the "ogis" consumed during the observational studies of dietary intake should be sampled, if possible, for moisture and nitrogen contents. The energy content of the dry weight equivalent of the "ogi" could then be assigned as the average of the published values for energy content of dry "ogis."

Forty-one specimens of maize "ogi" and 52 specimens of sorghum "ogi" are now available from the dietary studies. The moisture contents of the maize "ogis" ranged from 47.7 to 66.5% of the wet weights (mean ± SD, 58.1 ± 3.6%); the moisture contents of the sorghum "ogis" ranged from 45.6 to 84.6% of the wet weights (mean ± SD, 65.3 ± 8.7%). The distributions of these values are shown in Fig. 1. Results of the nitrogen analyses are still pending. The average nitrogen contents measured during the previous studies were, therefore, used to estimate the protein contents of the "ogi" paps for this review.

Table 3. Summary of previous studies of proximate composition of maize "ogi."

Proximate component and unit of analysis	**Akinrele (1967)[a]**	**Oke (1967)[b]**	**Banigo (1972)[c]**	**Ojofeitimi (1984)[d]**
Composition per 100 g wet weight				
Moisture (g/100 g)	54.6	93.9	41.0	73.2
Protein (g/100 g)	4.2	0.4	6.8	1.8
Fat (g/100 g)	2.3	0.2	2.3	0.4
CHO (g/100 g)	38.2	5.4	49.0	24.6
Energy (kcal/100 g)	190.7	25.1	244.3	108.8
Protein energy (%)	8.8	6.7	11.1	6.6
Composition per 100 g dry weight				
Protein (g/100 g)	9.2	6.9	11.5	6.7
Fat (g/100 g)	5.1	3.0	3.9	1.4
CHO (g/100 g)	84.3	89.3	83.0	91.6
Energy (kcal/100 g)	420.1	411.6	414.0	405.4

[a] Traditional, cooked cereal pap.
[b] Local ogi, oven-dried.
[c] Laboratory preparation, blended sample.
[d] Local ogi.

Table 4. Proximate composition of maize and sorghum "ogis" obtained from study villages.

Proximate component and unit of analysis	Type of "ogi" Maize (n=3)	 Sorghum (n=2)
Composition per 100 g wet weight		
Moisture (g/100 g)	54.0 ± 1.9[a]	68.2 ± 4.6
Protein (g/100 g)	3.5 ± 0.2	4.4 ± 0.1
Fat (g/100 g)	2.2 ± 0.2	1.7 ± 0.1
Crude fibre (g/100 g)	0.2 ± 0.1	0.9 ± 0.2
CHO (g/100 g)	39.8 ± 2.1	24.2 ± 4.2
Ash (g/100 g)	0.3 ± 0.1	0.7 ± 0.1
Energy (kcal/100 g)	193.0 ± 7.4	129.5 ± 18.5
Protein energy (%)	7.2 ± 0.5	13.8 ± 1.9
Composition per 100 g dry weight		
Protein (g/100 g)	7.6 ± 0.5	14.0 ± 1.9
Fat (g/100 g)	4.8 ± 0.5	5.4 ± 0.4
Crude fiber (g/100 g)	0.4 ± 0.1	2.9 ± 0.2
CHO (g/100 g)	86.5 ± 1.0	75.6 ± 2.1
Ash (g/100 g)	0.6 ± 0.3	2.1 ± 0.1
Energy (kcal/100 g)	420.0 ± 2.7	406.9 ± 1.1

[a] Mean ± SD.

Composition of Cereal Paps and Amounts Consumed

Quantitative studies of dietary intake were also completed in Laduba and Ago. Children between 5 and 30 months of age were included in daily, domiciliary surveillance for diarrheal diseases. Onset of diarrhea was defined as the excretion of four or more liquid or semi-liquid stools in a single 24-h period. In the event that diarrhea occurred, dietary studies were initiated on the following day. A 2nd day of study was completed during diarrhea, and 2 additional days during early convalescence and again 2 weeks after recovery. During all days of study, a dietitian remained in the household with the index child for at least 12 h. The ingredients of all recipe preparations and the amounts of food and liquids consumed were weighed to the nearest gram. Breast milk consumption was estimated by test weighing; total milk consumption during 24 h was assumed to be twice the 12-h daytime intakes. The energy and protein contents of breast milk were assumed to be 67 kcal/100 g and 1.1 g protein/100 g, respectively. The detailed methods used for these dietary studies have already been described (Brown et al. 1982; Brown 1984).

Results are now available from 36 children (23 boys, 13 girls); these results cover 199 days in which "ogi" was consumed during and after diarrhea. No "ogi" was consumed on seven of the days of observation; these days were, therefore, not included in the analyses. On six of the days, two types of "ogi" were mixed in unknown proportions; these days were also excluded. The age and nutritional status of the children at the time of the initial dietary study are shown in Table 5. The children were moderately stunted and

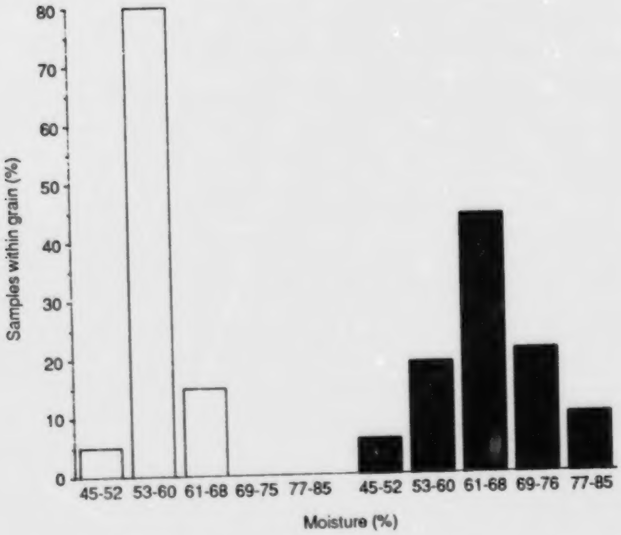

Fig. 1. Distribution of percent moisture content of maize (□) and sorghum (■) "ogis" (N = 41 maize and N = 52 sorghum "ogis").

wasted compared with the U.S. National Center for Health Statistics reference data (USNCHS 1977). Preliminary analyses indicated that the stage of illness or recovery did not influence the amount of energy or of protein consumed; all results are therefore considered, regardless of the individual's status (Table 6).

The "ogi" included in the paps was analyzed by type, and according to age group of children. There were 20 children under 12 months of age (range, 5-11 months) and 16 children of 12 months of age or over (range, 12-26 months). Because the composition of the paps was similar for both age groups, the data were combined. As shown in Table 7, about 50% more sorghum "ogi" than maize "ogi" was included in the paps. Because the sorghum "ogis" were more diluted,

Table 5. Age, weight, length, and relative nutritional status of children at time of initial dietary study (n=36).

Characteristic	Mean	SD	Min.	Max.
Age (mos)	12.1	6.2	5.0	26.0
Weight (kg)	7.52	1.79	3.9	13.4
Length (cm)	70.7	6.3	61.0	87.7
Length for age (Z)[a]	-1.34	1.46	-4.78	1.44
Weight for length (Z)[a]	-1.39	1.04	-4.80	0.99

[a] Z, number of standard deviations above or below the reference population 50th percentile for age or length.

Table 6. Mean (±SD) total daily energy consumption by food source and stage of illness.

Energy intake and source	Stage of illness Diarrhea (n=36)	 Convalescence (n=33)	 Postrecovery (n=30)
Total energy intake (kcal/kg per day)	85.9 ± 30.1	88.9 ± 23.3	81.3 ± 26.4
Energy intake from breast milk (kcal/kg per day)	64.1 ± 25.1[a]	64.2 ± 23.0[a]	55.9 ± 22.5[a]
Energy intake from pap (kcal/kg per day)	22.7 ± 12.8	20.7 ± 15.6	22.3 ± 13.8

[a] Only breastfed children included: n = 31, 28, 27, respectively.

Table 7. Composition of cereal paps by type of "ogi."

	Type of "ogi" Maize (n=385)[a]	 Sorghum (n=393)[a]
"Ogi" content of pap		
g wet weight/100 g pap	13.1 ± 8.0[b]	18.7 ± 10.7
g dry weight/100 g pap	5.6 ± 3.7	6.4 ± 4.1
Energy content of pap kcal/100 g pap	25.4 ± 15.6	26.9 ± 17.8
Protein content of pap g/100 g pap	0.44 ± 0.29	0.90 ± 0.58

[a] Number of servings.
[b] Mean ± SD.

however, the dry weights of "ogi" in the two types of paps were similar, as were their respective energy contents. Because of the greater protein content of sorghum "ogis" per unit dry weight, the protein content of the sorghum paps was correspondingly greater. Repetitive measures within groups of children may be highly correlated; caution should therefore be exercised in the interpretation of standard deviations; these and other analyses should be based not on individual children, but on servings or on days of observation. If these correlations are strongly positive, the standard deviations may be underestimated and vice versa. Future analyses of the completed data set will examine and, if necessary, adjust for this potential problem.

The distribution of the "ogi" contents and energy densities of the paps are shown in Figs. 2 and 3. The mean (±SD) energy density for all servings of pap was 26.2 ± 16.8 kcal/100 g. There was a positive, statistically significant relation between the energy density of a single serving of pap and the total energy consumed during the feeding (Fig. 4); children who received fewer servings of a particular type of pap tended, however, to receive pap with higher energy density (Table 8). On several occasions, other ingredients, such as sugar, egg, infant formula, or other flavouring agents, were added to the paps. Seventeen children received "fortified" paps

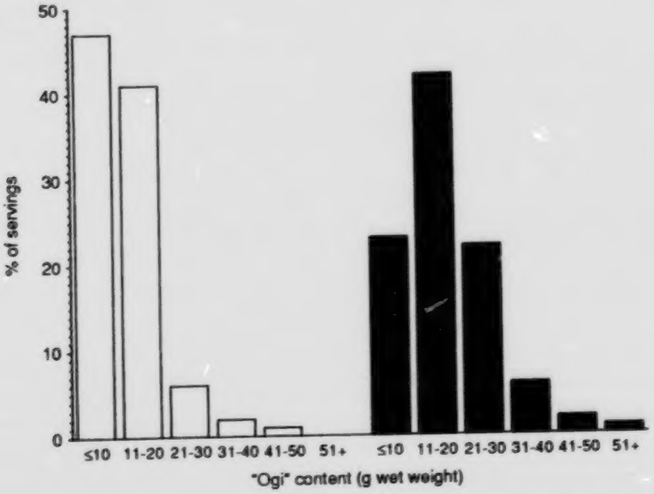

Fig. 2. Distribution of "ogi" content of cereal paps by type of "ogi" (□ , maize; ■, sorghum).

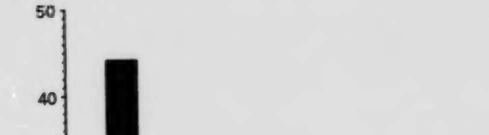

Fig. 3. Distribution of energy content of cereal paps.

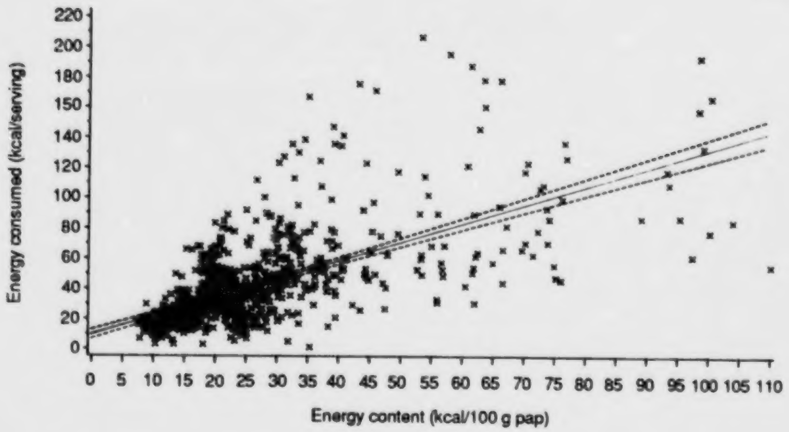

Fig. 4. **Relationship between energy density of pap serving (n = 774) and amount of energy consumed per serving. A simple linear regression line is shown with 95% confidence limits: $y = 9.723 + 1.216x$, $r^2 = 0.42$, $F = 569$, $p < 0.0001$.**

Table 8. Mean energy density (kcal/100 g pap) of cereal paps by number of feedings offered per day and order of serving (n=199 days of observation).[a]

Order of serving (number of days)	Number of feedings offered per day							
	1 (17)	2 (11)	3 (41)	4 (65)	5 (47)	6 (13)	7 (4)	All
1 (199)	46	45	29	26	23	25	15	28 ± 19
2 (182)		47	29	26	23	25	15	27 ± 17
3 (171)			29	27	22	25	15	25 ± 16
4 (130)				26	23	20	15	24 ± 15
5 (65)					25	19	16	23 ± 15
6 (18)						20	17	20 ± 9
7 (5)							22	22 ± 14
All	46 ±18	46 ±27	29 ±18	26 ±17	23 ±13	22 ±14	16 ±7	22 ± 9

[a] One child had eight servings.

during 38 days of observation. The average daily energy density of the supplemented paps was 35.6 ± 24.0 kcal/100 g; this is to be compared with 26.5 ± 15.4 kcal/100 g for those paps that were unsupplemented ($p = 0.03$). The protein densities of supplemented and unsupplemented paps were almost identical.

The amounts of paps offered and consumed during each serving were similar for both types of "ogi." These amounts are therefore presented by age group only in Table 9. Children over 11 months of age consumed

Table 9. **Amount of cereal paps served and consumed per serving or per day by age group.**

	Age group (months)	
	5-11 (n=484, 116)[a]	**12-26 (n=294, 83)[a]**
	Amount per serving	
Amount served		
g/serving	154 ± 39[b]	258 ± 97
g/kg body weight per serving	23.5 ± 7.2	32.4 ± 10.7
Amount consumed		
g/serving	129 ± 43	224 ± 86
g/kg body weight per serving	19.6 ± 7.3	28.6 ± 11.3
% of amount served	83.5 ± 16.9	87.6 ± 18.7
	Amount per day	
Number of servings	4.1 ± 1.1	3.5 ± 1.6
Amount served		
g/day	638 ± 210	894 ± 464
g/kg per day	98 ± 38	113 ± 66
Amount consumed		
g/day	532 ± 215	780 ± 481
g/kg per day	81 ± 37	101 ± 67
Energy consumed		
kcal/day	130 ± 80	203 ± 140
kcal/kg per day	19.6 ± 11.6	25.7 ± 18.3

[a] Number of servings; days of observation.

[b] Mean ± SD.

more pap per serving, both in absolute terms and in relation to their body weights. Children in both age groups consumed about 85% of the amount offered.

The individual servings of pap were summed by day of observation to determine the total amounts consumed (Table 9). Younger children received 1-7 servings per day (mean ± SD, 4.1 ± 1.1); older children received 1-8 servings per day (mean ± SD, 3.5 ± 1.6). The total amounts of pap consumed per day were greater among older children despite the slightly smaller average number of servings. Younger children received 20 kcal/kg body weight per day from paps, whereas the older children received approximately 26 kcal/kg per day.

All the younger children received breast milk during each of the days of observation (Table 10). The amounts that were consumed ranged between 128 and 1501 g/day (mean ± SD, 692 ± 289); these amounts yielded energy intakes from breast milk ranging between 12.6 and 137.1 kcal/kg body weight per day (mean ± SD, 68 ± 25). Eleven of the older children received breast milk on 60 days of observation. As expected, the older children received less breast milk and milk-derived energy than did the younger ones.

The total energy intakes from all sources averaged 87.7 kcal/kg body weight per day among the younger children and 83.0 kcal/kg per

Table 10. **Amount of breast milk and total energy consumed per day by age group.**

	Age group (months)	
	5-11 (n=116)[a]	12-26 (n=83)[a]
	Breast milk	
Amount		
g/day	692 ± 289[b]	606 ± 267[c]
g/kg body weight per day	102 ± 38	77 ± 34[c]
Energy		
kcal/day	464 ± 194	406 ± 179[c]
kcal/kg body weight per day	68 ± 25	52 ± 23[c]
	Total energy intake	
Amount		
kcal/day	593 ± 212	692 ± 288
kcal/kg body weight per day	87.7 ± 28.0	83.0 ± 31.4
% of FAO/WHO recommendations	90 ± 30	80 ± 30
% from specific sources		
Breast milk	77 ± 11	45 ± 31
Fermented cereal paps	23 ± 11	32 ± 19
Other	0	23 ± 35

[a] Number of days of observation. (No breast milk was consumed during 23 days of observation of children in older age group, and their values are not included in group means for breast milk variables.)

[b] Mean ± SD.

[c] n = 60.

day among the older ones (Table 10). These figures are 90 and 80%, respectively, of the Food and Agriculture Organization and the World Health Organization (FAO/WHO) recommended levels of energy intake for age (FAO/WHO/UNU 1985). Fermented cereal paps provided 23% of the energy consumed by younger children (100% of nonbreast milk energy) and 32% of the energy consumed by older children (58% of nonbreast milk energy).

Methods of Feeding

Because early observations from the ethnographic and quantitative dietary studies demonstrated the importance of hand-feeding, questions were added to the survey to determine the prevalence of this feeding technique. During hand-feeding, the child is usually held either supine across the mother's lap or with the head suspended from the mother's leg while she is seated. The mother then places her cupped hand over the child's mouth to serve as a funnel for a liquid or semiliquid food. When the child is unwilling to eat, the mother can force liquids into the child's mouth by simultaneously occluding the nose with her cupped hand; the child is then unable to breathe until he or she had swallowed all the food.

Health professionals, concerned that this feeding technique may produce an increased risk of aspiration pneumonia, actively discourage its use; the practice is, however, extremely common, and provides an efficient means of delivering relatively large volumes of food or liquids to a child in a very short period of time. As shown in Table 11, hand-feeding was seen to be practiced by roughly 63% of the 1022 mothers who were questioned. This feeding technique is used most commonly for infants between 6 and 11 months of age, both in the urban and the rural areas; its use declines as the children grow older. The practice is, perhaps, continued longer in rural households.

When mothers were asked during the ethnographic studies why they fed children in this way, many responded that it was "quick" and "saved time." In general, mothers said they "hand-fed" the baby unless he or she refused to accept the pap. When this occurred, nearly all said they would then "force-feed." Children who have decreased appetites (during diarrhea, for example) were thought to be prime candidates for force-feeding.

Maternal Feeding Practices

The foregoing findings on hand- or force-feeding led us, in the longitudinal dietary studies, to quantify feeding behaviour. We wished to determine whether, in fact, there were changes in feeding mode during and after diarrhea compared with illness-free days and if changes in behaviour affected the observed nutrient intakes during these intervals. Structured observations were completed to describe quantitatively the techniques employed for feeding "ogi." Strict operational definitions were developed, and extensive pilot testing of the instrument was carried out to reduce interobserver variation. The purposes of the structured observations were to ascertain the frequency of each type of feeding mode (hand-feeding, force-feeding, and spoon-feeding) during periods of diarrhea, convalescence, and health and to relate feeding technique to the nutrient intakes during these three stages of illness or recovery. As yet, only the former analyses have been completed.

Ten children were studied during 184 feedings. The results are preliminary only, and collection of data is still continuing. Of all servings of pap, 32% were hand-fed, 53% were force-fed, and 15% were spoon-fed. During most of these observations (84%), the child was in the reclining position that is required for hand- or force-feeding.

Table 11. Percentage of mothers reporting current hand-feeding, by age group and residence.

	Residence	
Age group (months)	**Urban**	**Rural**
0-5	67.3	69.3
6-11	86.7	82.9
12-17	77.3	76.4
18-23	35.7	64.8
24-35	22.0	24.5

The observational studies indicated that force-feeding occurred during 71% of the days of observation during diarrhea compared with 50 and 33% of days during early convalescence or postrecovery, respectively. The extremely small cell sizes preclude statistical testing, but it appears that the reported increase in force-feeding during diarrhea that was noted during the ethnographic studies may be correct. Whether this is in response to child anorexia cannot be tested at this time.

Summary and Conclusions

Given the frequency with which fermented cereal products are offered to infants and young children in southwestern Nigeria, we must recognize the importance of these foods. Often, they are the only nonbreast milk source of nutrients until well into the 2nd, and occasionally, the 3rd year of life. Unfortunately, the nutritional contribution of these foods to the total nutrient intake is limited by their low nutrient density when prepared as cereal paps.

The nutrient density of the paps is restricted by the viscosity of the cooked cereal products and by the cultural belief that infants and young children should not receive solid foods. It is unlikely that the volume of liquid pap intake could be substantially increased: during each serving, the average child consumes up to the extent of 2-3% of body weight - an amount that approaches the functional gastric capacity of children in this age group. It is not certain as to whether the number of servings offered per day could be increased; the time required for preparation and feeding of the pap would have to compete with a large number of other demands on the caretakers' time.

Possible interventions to improve the dietary intake of these children might include an earlier introduction of nutrient-dense solid foods, a fortification of the cereal pap with additional nutrient sources, or both. A source of amylase could possibly be added to these foods to reduce their viscosity. Because we feel that mothers would respond very reluctantly to the idea of an earlier introduction of solid foods, we have decided initially to promote fortified paps.

Locally available, low-cost energy supplements that could contribute to the energy density of liquid paps are palm oil and sugar. Palm oil has the advantage of providing greater amounts of energy and vitamin A and, possibly, of reducing the viscosity of the cooked pap. Potential protein supplements include cowpea, groundnut, melon seed, and soybean. Groundnut and melon seed are not ideal complementary protein sources because of their relatively low lysine contents; soybean would be an ideal complement, but is not yet commonly available in many parts of Nigeria (see Table 2). For these reasons, we have decided to develop recipes based on cereal paps fortified with palm oil and cowpea. Acceptability trials and clinical studies of the product are now underway.

One concern raised by the use of oil-fortified paps is the possibility of lipoid pneumonia in children who are hand-fed and who consequently aspirate some portion of the diet. We are therefore carrying out animal studies of lipoid pneumonia, using palm oil as the lipid source. The results of these studies will be taken into consideration during the planning of the final intervention program.

An alternative intervention strategy would be the promotion of spoon-feeding of the fortified cereal product. We plan to investigate the potential for a successful implementation of this change in feeding technique; it must be taken into consideration that spoon-feeding would probably demand a greater amount of time from mothers who are often already overworked. It must also be recognized that force-feeding, as currently practiced, may be a nutritionally adaptive mechanism, compensating for the extreme dilution of the cereal preparations; it may also help to overcome anorexia.

Acknowledgments

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FERMENTATION OF CEREAL- AND LEGUME-BASED WEANING FOODS

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Abstract *This paper reviews some common traditional methods in the preparation of predominantly cereal- and tuber-based weaning foods in Tanzania. The common observation is that most of these foods are of thin and watery consistency and are low in nutrient content. To meet the nutrient requirements of the growing child, therefore, the foods must be eaten in large quantities. Legumes are rarely used. The need is identified for the introduction of household-level techniques in the improvement of the nutritive value of weaning foods; methods for achieving this are reviewed. Results are given of preliminary investigations on the preparation and use, for preschool age children, of foods based on cereals, legumes, or both. Available information indicates that there exists the possibility of an improvement of the quality of cereal- and legume-based weaning foods through the use of simple, spontaneous fermentation.*

In most African countries including Tanzania, babies are fed exclusively on breast milk, breast milk substitutes, or both up to the age of 4-6 months. From this point to the age of 2-3 years, various forms of foods, semiliquid to solid, are introduced. At some time within this period, the children will be weaned off liquid milk altogether and will depend on foodstuffs prepared from root crops (cassava, sweet potatoes, yams) or from cereals (maize, sorghum, millet, rice) - rarely from legumes such as beans, green gram, or soybeans.

These foods are usually given in the form of gruels or boiled, semiliquid preparations. To achieve the desired free-flowing consistencies (FFC), slurries containing about 10% flour are used in the preparation of the gruels (Mosha and Svanberg 1983). The energy and nutrient concentrations of such preparations are usually too low; attempts have been made to reduce the viscosity of the gruels and to increase their concentration of dry matter. Mosha and Svanberg (1983) developed a simple technique of pregerminating sorghum grains to produce an amylase enzyme that hydrolyzes the starch in the grains.

This technique reduces the water-binding capacity of the flour, making it possible for gruels of suitable FFC to be made from slurries containing as much as 25% flour. Alternative technologies to improve the nutritive value of gruels for child feeding include the use of legume seed flours mixed with cereal flours. Further improvements in the consistency, flavour, and nutritive value may be achieved through the use of simple, spontaneous fermentation techniques. Such techniques have been in use for a long time in Asia (Herseltine and Wang 1972). The purpose of this article is to examine, in the context of Tanzania, both the potential and the limitations of fermentation technology in household-level preparation of weaning foods.

Preparation of Cereal Gruels

Cultural and ecological diversities in Tanzania lead to a varied use of weaning foods; these weaning foods may be classified into four groups:

- "single mix" is a weaning food composed of a single foodstuff, usually a cereal flour, made into porridge or gruel;
- "double mix" is a mixture either of cereal or of root crop flour or of bananas, prepared as mash with a little milk or animal fat;
- "triple mixture" contains starch sources, fruit, and vegetable mash; and
- "multimix" includes the varieties already mentioned, with the addition of any other food that the mother finds palatable and presentable.

Traditional Processing Techniques for Cereal "Uji"

"Uji" is the Kiswahili word used to describe a boiled liquid preparation of cereal grain flour. In Tanzania, the common practice is to boil a slurry of either maize, sorghum, millet, or cassava flour. Sugar and lemon juice are often added to bring out the flavour. When used for newly delivered mothers, butter or fermented milk is often used to enhance the flavour and the nutritive value. In certain parts of the country, particularly in the Tarime District bordering Kenya, it is common practice to prepare "uji" from a previously fermented slurry of maize and sorghum or millet flour. In Kenya, this practice is said to be quite common (Mlingi 1988). For the feeding of infants 4-6 months old, maternity and child health care (MCH) clinics recommend to mothers that the "uji" be prepared from cereal and groundnuts, in proportions of 1:1 (Semoka, personal communication).

The use of additives such as butter, milk, groundnuts, lemon juice, or fermented milk clearly indicates that traditional practice has taken care of the need to improve the nutritive value and flavour of "uji" made from cereals or tubers. We shall now address the question of whether or not fermentation can contribute to this improvement.

Fermentation of Cereal and Starchy Foods

The preparation of "gari," a cassava-based Nigerian foodstuff serves as an example of the "grass roots" application of fermentation technology in sub-Saharan Africa (Ketiku and Omololu 1988). In Tanzania, cassava is fermented at the household level by one of two methods: either it is soaked in water for 3-6 days, or it is chopped and covered with straw for the same length of time. It is then dried and pounded into a flour (Mlingi 1988). In certain areas, a covering of freshly cut grass or banana leaves is preferred and is believed to hasten fermentation to within 3 days, particularly when the cassava has not been left in the sun for too long after peeling.

Natural, spontaneous fermentation is also applied in the preparation of the maize starch cake food "ogi" and of a sour maize beverage known variously as "mahewu" in Southern Africa and "uji" in East Africa (Schwegart and Fellingham 1963; Akinrele 1970; Mbugua 1984). In West Africa, the processing of maize into "ogi" in Nigeria, or "akasa/koko" in Ghana, involves fermentation of the grain by the following method: the maize is soaked in water overnight, then wet-milled; the resulting paste is then mixed with water; this is followed by the filtration and decantation of the supernatant water. The remaining paste, mostly starch, contains the raw materials used in the final cooking of the "ogi" or "akasa" (Ketiku and Omololu 1988; Orraca-Tetteh 1988). Similar processing of maize is common in most urban areas in Tanzania. This type of flour (vividly white and starchy) has no common Swahili name, as opposed to "sembe" and "dona," prepared from dehulled maize and whole maize grain, respectively. Where this practice is used, the flour from the family pot would normally be used in the preparation of "uji" for infant feeding.

According to Mbugua (1984) in Kenya, "uji" is prepared predominantly from maize flour or meal; a mixture, however, of maize and millet or sorghum flours is sometimes preferred. The flour mixture is slurried with water and allowed to ferment at room temperature for 1-3 days, after which it is diluted to the desired consistency, then boiled and sweetened with sugar. The final pH of most "uji" preparation in Nairobi is more than 4.5. Typical "uji" samples have been prepared by making a 30% flour slurry mixture composed of 80% maize and 20% sorghum or millet in tap water and fermenting at 25°C (Mbugua 1984). To achieve a consistency suitable for the feeding of children at a temperature of about 40°C, the final dilution before boiling should bring the final flour content in the slurry to 8-10% (Mosha and Svanberg 1983; Mlingi 1988).

Fermentation of Cereal/Legume Mixtures

Fortification of cereal weaning foods with legumes is a widely recommended and practiced method in Tanzania. As mentioned earlier, a mixture of groundnut to cereal flour in proportions ranging from 1:1 to 1:2 is common (Semoka, personal communication). In Tanzania, the provision of at least one meal of cereal "uji" mixed with a legume or with milk is standard practice in nearly all preprimary nursery schools for children 3-6 years of age. At the Livestock Training Institute (LITI), Morogoro, the "uji" given to preschool children contains 3 parts maize meal and 1 part soybean flour, with the addition of sugar.

We investigated the fermentation characteristics of maize flour supplemented with increasing proportions of soybean flour. The flour mixtures were slurried in potable water at the rate of 10%, then left to ferment at room temperature. The pH development of duplicate determinations during a period of 48 h is shown in Table 1. Table 1 also indicates the stability of the heated gruels, and gives one person's judgment of their consistency and flavour. The inclusion of soybean flour in maize slows the pH development considerably: acidification is impaired with the inclusion of more than 50% soybean; at such levels, the water will separate out during the heating and cooling of the gruels. These preliminary results show that to produce an acceptable fermented product within 48 h, the quantity of soybean flour in the mixture should not exceed 40%; levels between 20 and 30% give a product with optimum consistency and flavour. A 70/30 mixture of maize/soybean is reported to give maximum improvement in the protein quality of weaning foods (Mitzer et al. 1984).

Legume Food Fermentations

Because they are widely available and contain quantities of protein and B vitamins, legumes are extremely important from a nutritional point of view. They provide excellent supplementation for the predominantly cereal- and root crop-based weaning foods in Tanzania. When pulses and cereals are mixed, they supply protein that contains adequate quantities of all the amino acids and is, therefore, of high quality (Latham 1965). It has also been found that the nutrient density of fermented cassava is increased through supplementation with legumes (Mlingi 1988). Some high-protein legumes, however, such as soybean (Glycine max) and winged bean (Psophocarpus tetryonolobus) are yet to gain popularity in Tanzania: intense beany odour and bitter taste are among the characteristics that have impeded their consumer acceptability.

In the Orient, soybeans have been eaten for centuries. The food prepared from these beans can be divided into two categories - unfermented and fermented. The preparation of fermented soybeans is perhaps the most common application of fermentation technology at the household level in the Orient. The major unfermented foods are soymilk, "tofu" or soymilk curd, yuba, kinako sprouts, and green soybeans. Many types of fermented foods or flavourings are prepared; some examples are "sufu," "natto," soysauce, and "tempeh." The general description of these products is given by Harris and Karmas (1975) among others. In Indonesia, pulverized "tempeh" combined with cereal-based porridge, salt, fish, or "tofu" is widely used as a weaning food.

Fermentation technology has also been used at Morogoro as a means of increasing the acceptability of the winged bean and its products. Winged bean mash was fermented separately with various proportions of cereal flours, such as rice, wheat, maize, and cassava. Yeasts and Pediocococcus predominated among the ferments. It was found that products fried in oil, similar to Indian "dosa" made from these ferments, were preferred to plain winged beans; winged beans and rice flour in 1:3 proportions produced the favoured "dosa" (M. Seenappa et al., unpublished).

Table 1. Fermentation characteristics of soybean/maize meal mixtures (10% mixed flour in water).

	% soybean flour										
	100	90	80	70	60	50	40	30	20	10	0
pH at 0 h	5.5	5.5	5.5	5.5	5.5	5.6	5.6	5.6	5.7	5.8	6.2
pH at 24 h	5.4	5.2	5.1	5.1	4.8	4.4	4.5	4.3	4.2	4.1	4.1
pH at 48 h	4.6	4.6	4.5	4.4	4.3	4.1	4.1	4.0	3.9	3.7	3.5
Stability on heating[a]	---	---	--	-	+	+	++	+++	+++	+++	+++
Viscosity at 40°C[b]	TTT	TTT	TT	TA	TA	A	AA	AAA	AAA	AAA	AAA
Flavour[c]	PPP	PPP	PPP	G	G	G	GG	GG	GGG	GGG	GGG

[a] ---, water separation at 40°C, very high; --, water separation at 40°C, high; -, water separation at 40°C, moderate; +, no water separation at 40°C; ++, stable gruel at 40°C; +++, normal gruel at 40°C.

[b] TTT, too thin; TT, thin; TA, thin but acceptable; A, acceptable; AA, good; AAA, very good.

[c] PPP, very poor; G, acceptable; GG, good; GGG, very good.

Influence of Fermentation on the Consistency of "Uji"

It should be expected that the presence of starch-hydrolyzing microorganisms will reduce the water-binding capacity of the slurries; a less viscous "uji" can therefore be obtained at higher levels of dry matter content. Studies, however, of the microbial flora of spontaneously fermented cereal "uji" or of "uji"-like products showed that amylolytic microorganisms were only a small proportion of the total flora (Akinrele 1970; Mbugua 1984; Mlingi 1988). To achieve sufficient starch hydrolysis, optimal conditions for the activity of the starch-hydrolyzing enzymes must be provided. Table 2 shows the principal starch-hydrolyzing enzymes and their optimal cultural conditions.

Both alpha- and beta-amylase have an optimal pH of 4.5 (Van Veen and Steinkraus 1970); below pH 4, their activity is greatly reduced (Mlingi 1988). Our own laboratory experience is that the pH of 10-30% maize slurry drops from about pH 6 to pH 4.1-4.4 within a 24-h incubation at room temperature (24-28°C). Amylases of germinated cereals (malt) in particular seem to be substantially active over a wide range of temperature (20-70°C). Beyond 70°C, their activity is greatly reduced (Mitzer et al. 1984). The duration of time of action does not seem to be critical.

Significant reduction of viscosity of gruels has been achieved within 5 min of the addition of alpha amylase or of germinated flour to starchy gruels (Karlson and Svanberg 1982; Mosha and Svanberg 1983). Were the type of spontaneous fermentation described by Mbugua (1984) producing sufficient quantities of amylases, neither the pH, nor the incubation temperature, nor the time duration would be

Table 2. Optimal conditions of amylolytic enzymes.

Enzyme	**Principal source**	**Optimal pH**	**Temperature (°C)**	**Effect on starch**
α-amylase	Pancreas, malt microorganisms (Candida tropicalis)	4.5-7	60-70	Breaks down starch to oligosaccharide with 6 or 7 glucose residues. Rapid decrease of starch viscosity.
β-amylase	Higher plants, cereals, malt, soybeans	4.5	50-60	Breaks down starch to maltose. Slow decrease of starch viscosity.
Amyloglucosidase	Bacteria, yeast, moulds (Aspergilus niger)	2.5-4.4	60	Breaks down starch to glucose. Industrial production of glucose from starch.

Source: Solms (1978).

limiting factors in the reduction of viscosities in such gruels. Available evidence (Table 3) indicates that fermentation by soaking in water does not favour amylase-producing microorganisms sufficiently to effect a noticeable reduction in viscosity.

On the other hand, air-dry fermentation of cassava seems to produce a marked amylolytic activity: this presumably is due to the presence of yeasts and fungi in larger quantities than would result from wet fermentation (Mlingi 1988). It would be interesting to investigate the possibility of enhancement of starch hydrolysis through the fermentation of moist doughs of cereal flours; conditions would need to favour the growth of yeasts, fungi, or both, and particular attention would have to be paid to the possibility of a growth of toxin-producing fungi and black moulds that could discolour the flours. On the basis of available information, it seems reasonable to conclude that fermentation of cereal gruels by soaking is not an effective means of reducing their bulkiness.

Effect of Fermentation on the Nutritional Value of Cereal and Legume Foods

Careful interpretation is required of studies on fermentation and the nutritive value of cereals: conflicting results may arise from differences in the assay techniques employed and in the microorganisms involved. Van Veen and Steinkraus (1970) concluded from various studies carried out in their laboratory that fermentation does not seem to improve the nutritive value of the protein; results of Akinrele (1970) did, however, show slight increases of 8 and 25% in total nitrogen and amino acid nitrogen, respectively, during traditional fermentation of "ogi." Earlier studies (Rajalakshmi and Vanaja 1967; Akinrele 1970; Van Veen and Steinkraus 1970) and more recent ones (Hamad and Fields 1979; Aliya and Geervani 1981; Kazanas and Fields 1981; Murdock and Fields 1984; Nanson and Fields 1984; Dhankar and Chauhan 1987) all seem to agree that fermentation increases the content of certain vitamins, particularly thiamine, riboflavin, and to a lesser extent, niacin. At the same time, a decrease in some vitamins, particularly pantothenic acid, has been recorded (Akinrele 1970; Van Veen and Steinkraus 1970).

Improvements in nutritive value have also been shown to occur during the fermentation of legume foodstuffs; an example is provided

Table 3. Effect of fermentation techniques on viscosity of gruels.

Treatment	Effect on viscosity	Source
Soaking sorghum flour overnight	No reduction in viscosity	Mosha and Svanberg (1983)
Soaking cassava chips in water for 3-6 days	No reduction in viscosity	Mlingi (1988)
Air-dry cassava chips for 3-6 days	22-50% reduction in viscosity	Mlingi (1988)

by "tempeh," made from fermented soybean (Gyorgy 1962). Such improvements have been attributed to increased digestibility, brought about by proteolysis of the complex proteins to peptides of varying length and amino acids (Smith and Circle 1972). Similar changes have been shown to occur during the fermentation of "idli," an Indian product made by mixing black gram (Phaseolus mungi) and rice (Gyorgy 1962). There is, therefore, adequate scientific evidence to show that the chemical changes taking place during the fermentation of legumes enhance their nutritional quality. The processing methods used for the preparation of flours also influence considerably the nutritive value of the cereals produced. The West African method of processing the flour of "ogi" or "akasa" is wasteful of nutrients and has been shown to result in a decrease of protein content by as much as 50% and of fat extract by 27% (Ketiku and Omololu 1988). The best products, from a nutritional point of view, are those prepared from whole grain meals. There is, no doubt, an additional but small improvement in the nutritional value as a result of fermentation. This improvement, however small, should be fully exploited in the feeding of children. Other advantages of traditionally fermented foods include ease of digestibility, better storage capability, enhanced flavour, and reduction in cooking times (Van Veen 1970; Harris and Karmas 1975).

Acceptability of Fermented Cereal/Legume Foods

Whatever the nutritional advantages of a food, the following factors will determine its consumption by the targeted consumer group: relative cost, availability, and organoleptic acceptability (acceptability of its flavour). In this latter respect, fermented foods usually present an improvement over the unfermented (Herseltine and Wang 1972); this improvement has been attributed to the production during fermentation of lactic acid, carbon dioxide, alcohol, various flavour compounds, and changes in texture (Pederson 1971).

The decision was made to test the acceptability of fermented gruels for preprimary nursery school children 3-7 years of age. Forty-five children of the Sokoine University Nursery School were used in the test. Maize flour prepared for normal domestic use (the making of hard porridge) was slurried in water at the rate of 10%. About 5 L of the slurry was incubated at ambient temperature for 48 h, during which the pH dropped to 4. As a control, 5 L of gruel of unfermented flour was prepared on the test day. To both samples, sugar was added at the rate of 4%. The samples were presented to the children in a paired preference test. The same experiment was repeated with unfermented gruel, acidified to the same pH as the fermented control sample. Forty-eight children participated in this test.

The results showed that when fermented "uji" of pH 4 was offered along with unfermented "uji," 58% of the children preferred the former; this preference was not, however, significant at $P \leq 0.05$. In the second trial, the children were asked to choose between "uji" acidified, with lemon juice, to the same pH as the fermented "uji"; 60% of the children preferred the former. It can be inferred from these results that the children did not show a preference for either product. Although these results are only preliminary, they show that because of the improved nutritional quality and flavour of fermented "uji," the provision of this food to preschool children should be encouraged.

Summary and Conclusions

It is clear from the scientific evidence cited in this article and from observations made on traditional practices that several options exist for an improvement of the nutritional value of cereal-based weaning foods. Supplementation with legumes is a practical way of improving the protein quality of cereal gruels and is a practice that is both widely recommended and widely followed in Tanzania. Traditional fermentation techniques do not appear to cause sufficient starch hydrolysis to influence significantly the dietary bulk of the gruels; such is not the case with germinated flours. Modifications that favour the growth of amylolytic microorganisms and lactic acid producing bacteria would have to be developed to enable the production of gruels with higher nutrient densities. Results of preliminary investigations showed that fermentation did not impair the acceptability of gruels among preschool children tested. It is concluded, therefore, that fermented gruels can, to some extent, be used to improve the nutrition of children.

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REDUCING DIETARY BULK IN CASSAVA-BASED WEANING FOODS BY FERMENTATION

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Abstract *Fermentation is an ancient food-processing technique, employed in the preparation of cassava flours for home consumption. This study compares two types of fermentation procedures practiced at the village level in Tanzania. In the first procedure, sliced cassava chips are soaked in water for 3 days; in the second procedure, the sliced cassava chips are heaped together and covered with straw for 3 days (air-fermentation). Cassava flours processed by these two methods were used to make three types of cassava flour porridges (with one type of flour unfermented); viscosity measurements were then carried out on these porridges. Viscosity curves, obtained after plotting viscosity against percentage concentration, showed that viscosity is reduced in fermented cassava flours, especially those that are air-fermented, and is reduced still further in cassava flours mixed with legumes. This use of legumes also creates higher nutrient densities in the porridges.*

Cassava (Manihot esculenta Krantz) tuber is known to be the fourth most important source of food energy in the tropics. More than two-thirds of its total production is used as food for human consumption; the remainder is used for animal feed and for industrial purposes. Its importance as an energy source lies in the fact that its roots are rich in carbohydrates. When the flour from cassava roots is cooked into a gruel (porridge), however, the starch granules bind large amounts of water; this results in a gruel of high viscosity. A gruel with a low dry matter content of, for example, 10% will have a low energy density, thus contributing to an inadequate intake of energy; this problem has been recognized by the United Nations Protein-Calorie Advisory Group (PAG), who focused attention on the use of more energy-rich supplements, such as fats, in the preparation of weaning foods (PAG 1973; Waterlow and Payne 1975; Cameron and Hofvander 1976; Dearden et al. 1980). Rutishauser and Freed (1973) and Rutishauser (1974, 1975) have discussed the relative importance of energy density, feeding frequency, and appetite (taking into consideration the presence of acute illness) with regard to the energy needs of preschool children; in these discussions, it was noted that energy density was the most decisive factor. Data from these studies showed that in cases of discontinued breastfeeding, it was almost impossible to compensate fully for the energy deficit with foods other than milk: compared with other (starch-based) foods, milk seems to have "specific" dietary-bulk properties that may be explained by a lack of water-binding components.

Church (1977) discussed the aspect of consistency with regard to weaning foods, particularly in relation to age and development, as well as to disease in children. The preference for liquid foods is higher in younger children, and increases with the severity of a disease. Higher liquidity, however, means decreased energy density when the diet is based on starchy staples. Church also noted that foods with a high fat content become palatable without the addition of much water during preparation. The importance, therefore, of fat in the diet is twofold: first, it increases the energy content of the diet; second, the food does not have to be diluted with water to become palatable.

Dietary Bulk in Weaning Foods

Studies have been made of the feeding of preschool children in areas where starches are the staple foods and where protein energy malnutrition (PEM) is prevalent; these studies show that the bulkiness of the diet is the major constraint against adequate food consumption. When cassava flour is made into a gruel, the starch granules bind large amounts of water; this results in a gruel that is thick. If a more liquid consistency is preferred for child feeding, the traditional way to obtain it is to dilute the gruel with more water, thus decreasing its energy and nutrient density. The child must then eat larger portions to satisfy his or her nutrient requirements.

This phenomenon of high volume or viscosity in a food is known as "dietary bulk," and its significance in relation to child-feeding practices is serious for populations that depend entirely on starchy staples as the main source of energy for both young children and adults (Ljungqvist et al. 1981). Observations and experience show that PEM is suffered by many children who are fed only gruels made from starchy staples. This problem can, however, be alleviated by reducing the dietary-bulk properties of such staples; this can be done either by fortifying the starch staples before cooking or by modifying the starch granules or structures when processing them into flour.

Dietary bulk is often mentioned as a possible or even probable factor in the etiology of malnutrition (Rutishauser 1975; Waterlow and Payne 1975; Ljungqvist et al. 1981). Very few attempts, however, have so far been made to study systematically the importance of dietary bulk in the feeding of children. Although some authors have observed that starch-based diets have a very bulky appearance (Jones and Pereira 1972; Binns 1975), it is not clear if they refer to the volume or to the consistency of the diet. Studies by Nicol (1971), who attempted some quantitative estimates of the dietary bulk factor based on food intake, show that the volume of starch-based foods required daily to cover the energy needs of preschool children is between 900 and 1650 mL. For diets based on cereals, such as sorghum or rice, this volume could be consumed only if the children were fed four meals per day; in the case of starchy roots, it may be impossible to eat the required amount.

Effects of Fermentation on Cassava Processing

Fermentation is a common, traditional, food-processing method used at the household and village levels. The main role of fermentation in food processing lies in the nutritional upgrading of the foodstuff. Examples are provided by traditional food fermentations and probably by koji-type processes for the industrial production of enzymes: these procedures use natural raw materials such as soybeans, rice, or wheat bran - all containing appreciable amounts of protein. During the growth of the mould, plant protein is broken down and reformed into mycelial protein; there is, however, no net production of protein (Van Veen and Steinkraus 1970). Other nutritional advantages - flavour improvement, colour change, smell, etc. - may, however, result from fermentation. In addition to its role in the upgrading of foodstuffs, fermentation has a significant effect in reducing the bulk properties of starchy foods, thus reducing overall dietary bulk.

Many small-scale cassava fermentation processes have been studied and show an increase in protein content by a factor of 6-8 (Hendershot et al. 1972). This increase in protein content results either from a conversion of the starch to protein during fermentation or from the mycelial or microbial protein of the organisms involved in the fermentation. Like germination or malting, fermentation involves the action of enzymes: various microorganisms produce a variety of enzymes that act on the substrate, changing its original form. A number of microorganisms have been identified in cassava fermentations. Besides the "Corynebacterium manihot" and Geotricum candida reported by Collard and Levi (1959), there is a diversity of fungus-like Aspergillus, Penicillium, Rhizopus, Botryodiplodia, Mucer, Fusarium, Cunninghamella, and Syncephalastrum species; these have been identified by Brook et al. (1969). Among the diversified bacteria involved in cassava fermentations are Leuconostoc, Alcaligenes, and Lactobacillus species, reported by Okafor (1977); Streptococcus, Maracella, and Acinetobacter species were reported by Ngaba and Lee (1979). Ngaba and Lee also isolated one type of yeast, Bettranomyces sp., involved in the fermentation.

In fermentation, starch is degraded by enzymes (especially amylases produced by certain microorganisms) and is changed into simpler forms such as the simple sugars. It has been shown that some microorganisms involved in fermentation have the enzymes needed for the hydrolysis of starch into simple carbohydrates. For example, when, in the process of enriching cassava with protein, Candida tropicalis was grown on cassava starch during fermentation, the resultant biomass mixture and residual cassava contained about 20% protein - an amount sufficient either for animal fodder or for human food (Azoulay et al. 1980). Candida tropicalis grows on soluble starch, corn, or cassava powders without requiring previous hydrolysis, and it possesses the enzyme (alpha-amylase) needed for the hydrolysis of the starch. There are no extra enzymes required to hydrolyze starch in such fermentation; it is, therefore, a particularly efficient way of improving the nutritional value of amylaseous products by means of a single fermentation process.

To influence starch degradation in a fermentation process, conditions should be selected that both favour amylase-producing microorganisms and inhibit pathogenic organisms. In Tanzania, two methods of fermentation of cassava are practiced at the village level. In the first method, the sliced cassava roots are soaked in water (usually for 3-6 days), then dried and pounded into flour. The soaking results in a fermentation that will partially break down the starch structure; as a consequence, the swelling behaviour of the starch will be significantly reduced. In the second type of fermentation, the sliced roots are heaped together (again for 3-6 days); this provides an opportunity for moulds and other microorganisms to act on the cassava, and utilizes the action of enzymes secreted by these microorganisms.

Tests have been made that demonstrate a reduction in viscosity as a result of enzymes released during fermentation and during the germination of cereals. Karlsson and Svanberg (1982) treated unfermented and fermented cassava flour gruels with 3 mg alpha-amylase and 3 mL saliva, respectively, and showed a significant decrease in viscosity (Table 1).

Viscosity of gruels can be measured using either a Brabender amylograph apparatus or different types of viscosimeters. The Brabender amylograph usually monitors viscosity during a standardized heating and cooling cycle; a viscosimeter gives viscosity readings directly at a given concentration. A Brabender amylographic apparatus with a shear rate of 75 rpm can be used at temperatures that rise at an interval of 1.5°C/min from 25 to 95°C, kept constant at 95°C for 10 min and then decreased by 1.5°C/min during cooling to about 40°C.

Table 1. Reduction in viscosity after 5 min of addition of alpha-amylase or saliva to gruels made from different flours.

Mixture and percentage dry matter[a]	**Enzyme treatment**	**Reduction in viscosity in percentage of initial value**	**Viscosity after 5 min of adding the enzyme (BU)[b]**
Weaning food[c]			
"Lisha," extruder, 17%	3.0 mg alpha-amylase	86	170
"Lisha," raw materials, 17%	"	91	50
"Faffa," 20%	"	95	60
Flours[d]			
Maize, 10%	"	92	60
Cassava, unfermented, 10%	"	98	20
Cassava, fermented, 10%	"	98	20
Cassava, fermented, 10%	3.0 mL saliva	98	20

Source: Karlsson and Svanberg (1982).

[a] In Brabenber amylograph: volume, 450 mL; temperature, 38°C.

[b] BU, Brabender units.

[c] Prepared according to recipe: "Lisha," weaning food industrially manufactured in Tanzania; "Faffa," weaning food industrially manufactured in Ethiopia.

[d] Dry matter amount chosen to give a thick gruel at 38°C after cooking.

The temperature is kept constant for 10 min at 95°C to allow complete cooking of the flour or starch. The gruel is then cooled to 40°C - a good serving temperature; below this temperature, the viscosity is very high.

Viscosity of gruels is also measured directly on viscosimeters in which instruments such as a Haake Rotovisco model RVI with an FK/SVII measuring system and a shear rate of 162 rpm could be used (Hellström et al. 1981); a Brookfield viscosimeter could be used instead (Brandtzaeg et al. 1981). The ingredients to be measured are mixed with water in the measuring device, and the temperature increased by 1.5°C/min from 50 to 95°C; the temperature is kept constant at 95°C for 10 min, and then finally lowered by 1.5°C/min during cooling to 50°C. All samples under viscosity measurements must be homogeneously mixed and stirred before being poured into the viscosimeter. The pH adjustments can be made by adding 6 M hydrochloric acid or 3 M sodium hydroxide (NaOH) to the gruels before initiating the measurements.

Studies of Dietary Bulk in Cassava Flours

Studies were undertaken of dietary bulk in cassava flours. The objective was to determine whether the bulk properties of these flours constitute a limiting factor in nutrient intake from cassava flour gruels.

Materials and Methods

Six samples of cassava flour were used, each differently processed and obtained from the Kawe area, Dar es Salaam. These samples were processed from both sweet and bitter varieties, distinguished by the chewing of a small piece of the peeled tuber. The processed samples are identified as follows:

- Sweet fermented and unfermented flours;
- Bitter fermented and unfermented flours; and
- Mixed (sweet and bitter) wet-fermented and air-fermented flours.

("Wet-fermented" indicates fermentation by soaking in water; "air-fermented" indicates fermentation without soaking in water; "unfermented" indicates direct drying of peeled tubers in the sun.)

The cassava tubers were dug from the ground, washed with water to remove the sand, and then peeled. They were then split to remove the midrib and sliced into small pieces (chips). The tubers that were to remain unfermented were spread on a mat outside for sun drying; those intended for wet-fermentation were soaked in a bucket of water and left for 3 days. The air-fermented tubers were heaped together in the shade, covered with straw, and then left to ferment for 3 days. After fermentation, the soaked tubers were spread on a mat for sun drying, and the soaking water was thrown away. After satisfactory drying, the cassava chips were taken to a nearby village hammer mill and ground into flour.

Cassava flour gruels studied in this experiment were prepared in the laboratory by mixing a known weight of cassava flour with a known volume of distilled water to make a required concentration: 50 g of flour, for example, mixed with 450 mL of distilled water, gave a gruel of 10% dry matter. The mixture was heated in a boiling water bath to a cooking temperature of 95°C for 10 min, and then allowed to cool. Gruels of concentrations of 2.5, 5.0, 7.5, and 10% were prepared for viscosity measurements from the unfermented, wet-fermented, and air-fermented flours.

For purposes of comparison, gruels from the same flours mixed with legumes (beans and groundnuts) were prepared using the same procedure. Cassava flour was mixed with bean flour at a ratio of 1:1 and with groundnuts at a ratio of 4:1. After two portions of the respective mixtures had been mixed, they were homogenized by a Sovall Omni Mixer 230. From the homogenized mixtures, gruels of the required concentrations were prepared as described above.

The viscosities of all the gruels prepared were measured using a Haake Rotovisco Model RVI with an FK/SVII Profiled measuring system and a shear rate of 54 rpm. The measuring temperature was kept at 40°C to allow comparison of different concentrations (5-10%). The viscosity behaviour of the gruels was investigated with a Brabender amylographic apparatus with a shear rate of 75 rpm (Hallick and Kelly 1959).

Results

Gruels either of unfermented or of wet-fermented flour of both varieties have about the same viscosity at the same concentration (Table 2). By comparison, the air-fermented flour produces gruels with significantly lower viscosities. The concentration/viscosity curves for the three types of gruels in Table 2 are represented in Fig. 1.

The viscosity of cassava flour gruels mixed with either groundnuts or broad beans is shown in Fig. 2. A reduction in viscosity is seen when either of the legumes are mixed with unfermented or with wet-fermented cassava flour. Mixing legumes with air-fermented flour results in only a small decrease in viscosity.

Table 2. Viscosity (cP) of cassava flour gruels at different concentrations.

Type of cassava flour	Concentration (%)			
	2.5	5.0	7.5	10.0
Sweet, unfermented	245	1455	3070	5580
Sweet, fermented	325	1575	3350	5290
Bitter, unfermented	160	765	2020	4445
Bitter, fermented	240	1290	2785	4875
Mixed, air-fermented	160	725	2385	3390

Note: 1 P = 0.1 Pa s.

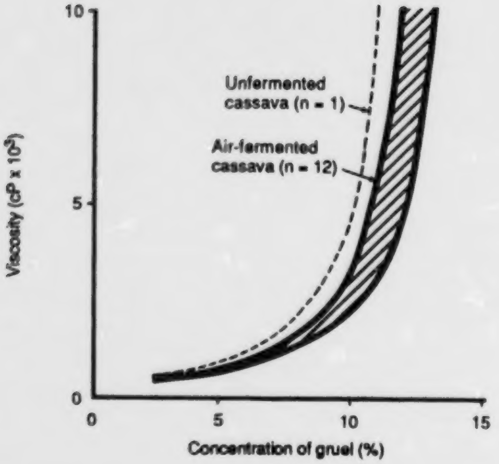

Fig. 1. Viscosity curves of various gruel concentrations of cassava flours (1 P = 0.1 Pa s).

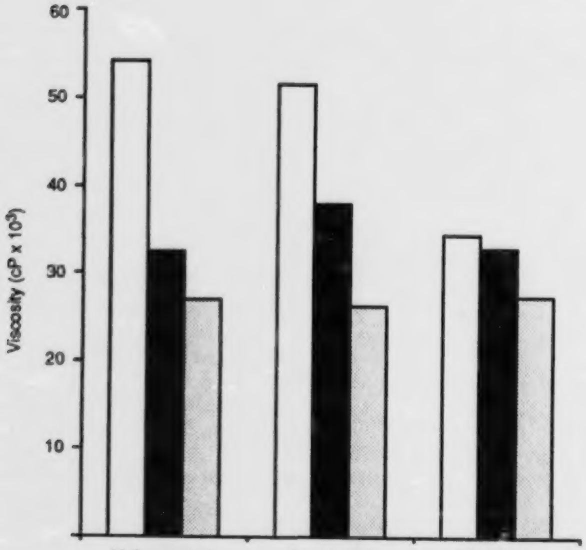

Fig. 2. Viscosities of sweet and mixed cassava porridges at a concentration of 10%, before and after mixing with legumes (1 P = 0.1 Pa s). □, without legumes; ■, mixed with groundnuts (4:1); □, mixed with broad beans (4:1).

The calculated energy density of cassava flour gruels with or without legumes at a consistency of 3000 cP (1 P = 0.1 Pa s) (measured at 40°C) is shown in Table 3. Gruels of unfermented cassava flour have an energy density of about 0.28 kcal/g; a gruel of air-fermented flour has an energy density of 0.34 kcal/g. When mixed with legumes, the energy density of the gruels is increased to between 0.36-0.41 kcal/g.

Discussion

Results of the viscosity measurements made on cassava flour gruels are shown in Table 2 and represented in Fig. 2. Although the measured viscosities of the fermented and unfermented flours do not differ, it seems that the soaking of cassava chips in water (wet-fermentation) for some days does not particularly affect the starch structure; it appears that, in this treatment, the cassava starch is still able to bind water molecules in the same way as the unfermented cassava flour starch. The enzymes responsible for starch degradation, such as alpha- and beta-amylases, seem not to have been released by those microorganisms developed during the liquid fermentation process; one type of starch-hydrolyzing bacteria and one type of starch-hydrolyzing yeast were, however, detected (Table 4). The amylase activity is usually higher in yeasts than in other fungi groups; the larger amount of enzyme activity found in moist, solid- or air-fermented flour (in which a great deal of mould can grow) might explain the reduced viscosity observed in gruels made from such flour. It has been reported that during the wet-fermentation of cassava tubers, there is a decrease in pH, during which the flesh becomes soft (Ogunsua 1980).

The decrease in pH may be responsible for the failure of the amylase to act on the starch - breaking its structure and thus reducing viscosity. Below pH 4, the activity of amylases is strongly reduced. In the production of "lafun" (cassava flour in Nigeria), in which whole tubers are soaked in running water, it was observed that

Table 3. Energy density in cassava flour gruels at a viscosity of 3000 cP with or without mixing with legumes.

Type of cassava flour	Concentration at 3000 cP (g)	Energy density (kcal/g)
Sweet unfermented flour	7.4	0.27
Sweet unfermented flour + groundnuts	8.88	0.37
Sweet unfermented flour + beans	10.2	0.37
Sweet fermented flour	7.0	0.25
Sweet fermented flour + groundnuts	9.4	0.38
Sweet fermented flour + beans	10.3	0.36
Bitter unfermented flour	7.85	0.29
Bitter fermented flour	8.55	0.32
Mixed air-fermented flour	9.15	0.34
Mixed air-fermented flour + groundnuts	9.6	0.41
Mixed air-fermented flour + beans	10.2	0.37

Note: 1 P = 0.1 Pa s.

Table 4. Content of microorganisms in cassava flour samples.

	LAB	LAB[a]	Bacilli	Coliforms	Spores	Yeasts	Yeasts[b]
A	2×10^{5}	125×10^{8}	33×10^{6}	54×10^{6}	5×10^{3}	7×10^{3}	12×10^{3}
B	5×10^{5}	136×10^{8}	97×10^{7}	121×10^{7}	18×10^{3}	12×10^{3}	27×10^{3}

Note: A, wet-fermentation; B, moist, solid- (air-) fermentation.
[a] Starch-hydrolyzing bacteria.
[b] Starch-hydrolyzing yeasts.

the pH dropped from 4.5 to 3.9 (Waterlow and Payne 1975). Wet-fermentation of cassava tubers therefore has little or no effect on the bulk properties of the flour; rather, it results in a soft, whitish product, preferred by many village people. On the other hand, air-fermented (moist, solid-fermented) flour showed lower values of viscosity (Table 2) compared with other flours. This type of fermentation can therefore have an effect on the bulk properties of the flour. Mould always grows in abundance during air-fermentation; to promote the growth of amylase-producing moulds, yeasts, or both, the processing conditions should be studied further.

A reduction in viscosity was also observed in cassava flour gruels to which legumes (beans and groundnuts) had been added. This effect is explained by the higher water-binding capacity of the cassava flour as compared with the groundnut and bean flour.

The energy densities of the flours were calculated at a fixed viscosity (3000 cP) for unfermented, wet-fermented, and air-fermented flours, together with those mixed with legumes at known proportions (Hendershot et al. 1972). As shown in Table 3, those flours mixed with legumes of slightly higher energy densities have been increased in the mixtures; as was shown, however, in a village study made in Tanzania, the energy density (1.2 kcal/g) is still below that needed to satisfy the energy requirements of preschool children. For these energy requirements to be met, it is extremely important that ways be found to reduce further the water-binding capacity of cassava flour.

Conclusions

From these investigations, we see that air-fermentation of cassava roots (and thus of cassava flours) reduces viscosity significantly. Although fermentation by soaking in water has no marked effect in reducing viscosity, the procedure results in a whiter flour than is produced by air-fermentation. When legumes are mixed with cassava flour gruels, the energy density of the latter is significantly increased; this implies that a combination of fermentation and fortification or mixing with legumes would provide an optimum increase in nutrient density. It was also observed that fortification reduced the viscosity of such gruels. Among the two cassava varieties studied, the sweet-fermented variety seemed to have a higher water-binding capacity (viscosity) at certain concentrations than did the bitter cassava.

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FERMENTED CASSAVA PRODUCTS IN TANZANIA

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Abstract *Descriptions are given of the traditional methods for preparing "udaga," "kivunde," and "makopa" (fermented cassava products) from cassava roots. Microorganisms and chemical constituents were investigated in relation to fermentation in these products; in all three, there was found to be variation in microbial content, in organic profile, and in endotoxin levels. Although "udaga" was found to be safe for child feeding, information is required on its nutritional quality. "Makopa" was found to contain high levels of nontoxic moulds that were amylolytic. Because they hydrolyze starches, these moulds help to reduce the viscosity of the gruel and, thus, to reduce dietary bulk. "Makopa" also had a high number of bacteria from the family Enterobacteriaceae. It is possible that these bacteria are destroyed on cooking; more information is required, however, on the safety of the gruel prepared from "makopa" flour.*

Cassava tuber is known to be the fourth most important source of food energy in the tropics. Its importance as an energy source lies in the fact that its roots are high in carbohydrates. The major part of the carbohydrate, however, is starch, and starch-based foods are bulky.

When cassava flour is made into a gruel, the starch granules bind large amounts of water; this results in a gruel of thick consistency. If a more liquid consistency is preferred for child feeding, the traditional way to obtain it is to dilute the gruel with more water, thus decreasing its energy and nutrient density. A child must therefore eat a quantity large enough to satisfy his or her nutrient requirements. Observations and experience show that protein energy malnutrition (PEM) is suffered by many children who are fed only gruels made from starchy staples. This problem can, however, be alleviated by reducing the dietary-bulk properties of such staples: this can be done either by fortifying the starch staples before cooking, or by modifying the starch granules or structures when processing them into flour.

Mlingi (1984) reported that dry fermentation of cassava roots significantly increases the protein content of the flour and reduces the viscosity of cassava-flour porridge.

Indigenous fermentation of cassava roots is widely practiced in Africa. Fermentation of cassava mash for "gari" production, and the soaking of whole or peeled roots for "lafun" or "fufu" production, are the two processes popular in West and Central Africa; processes based on the growth of moulds are preferred in East Africa (Lancaster et al. 1982; Steinkraus 1983).

Little information is available, however, on fermentation processes in Tanzania. Mlingi (1984) mentions two processes: the first is that of soaking the peeled roots in water; the second is that of covering the semidried roots with banana leaves or gunny sacs for 2-3 days. Hakimjee (1985) made preliminary efforts to isolate amylolytic microorganisms from the product of the latter method.

Fermentation of the tubers is effected mainly in the following three ways:

- The cassava roots are peeled (thick roots being sliced in half) and put out in the sun until they are golden brown. They are stacked and covered with banana leaves and left to ferment for 2-3 days, until moulds appear; then they are sun dried. Some people scrape the moulds off before pounding. This process is common along the coast and in the southeast regions and produces a flour called "makopa."

- The cassava roots are peeled, sliced into small pieces, and washed. The pieces are soaked in water for 2-3 days until they are soft; they are then removed from the water, squeezed, and spread out in the sun to dry. The dried product is ground to flour. This process is common in the southwest regions; the resultant flour is called "kivunde."

- The cassava roots are peeled, sliced, and mashed on rocks or between stone surfaces. This mash is wrapped in gunny sacks or in any rough cloth, and left to ferment for 4-5 days, after which it is sun dried and ground to flour. This process is popular in the northern lake zone area, and produces a flour called "udaga." This flour is consumed as a thick sticky mass ("ugali") or as a porridge ("uji").

Because diarrhea is also a contributory factor in malnutrition, information is needed on microorganisms present in the fermented cassava and on other aspects of fermentation. Such information would allow the utilization of this household-level technology for child feeding, improving nutrient intake while at the same time ensuring the safety of the product.

This study focuses on the isolation and identification of microorganisms from these products, with special reference to the safety of the food, to the role of lactic acid producing bacteria (LAB) in fermentation, and to the amylolytic activity of the microorganisms.

Materials and Methods

About 200 g of traditional fermented cassava roots, sun dried and pounded, were taken as samples from the villages where they had been prepared. Eleven samples of "makopa," 10 samples of "kivunde," and 10 samples of "udaga" were analyzed.

Standard microbial procedures were followed in the analysis. The total count of bacteria from the family Enterobacteriaceae, *Bacillus* spp., LAB, yeasts, and moulds were enumerated. The isolates were examined by morphology and by biochemical reaction. Gram differentiation of bacterial isolates was done according to the method of Suslow et al. (1982).

The biochemical tests carried out on isolates were those pertaining to their catalase activity, to their oxidase activity, and to their ability to hydrolyze starch. Identification of bacteria from the family Enterobacteriaceae was done by means of biochemical tests using the Minitek Enterobacteriaceae II method (Identification System 25193, BBL Microbiological Systems, Becton-Dickinson, ND, USA). Spore-forming *Bacillus* were identified according to the method of Seenappa and Kempton (1981). Yeasts and moulds were identified according to Samson et al. (1984). LAB were identified by reference methods from Bergey's Manual (19/4) and by biochemical tests in API 50 CHL Lactobacillus (API Systems SA, La Balme Les Grottes 38390, Montalieu, Vercieu, France).

The pH was measured with a pH meter. Organic acids were analyzed using High Performance Liquid Chromatography. Endotoxin was measured with the Limulus amoebocyte lysate method (Coatest Endotoxin Manual Method, KabiVitrum S-112 87 Stockholm, Sweden).

Results and Discussion

Table 1 shows the variation in the number of microorganisms in three different products. The pH of cassava is usually around 6.0. In our study, "udaga" had a low pH range of 4.5-6.0 and no bacteria from the family Enterobacteriaceae (Table 1). Table 2 also shows that "udaga" had more lactic acid as compared with other products. LAB fermentation causes an accumulation of organic acids, reducing the pH of the product; this is known to reduce the bacteria within the family Enterobacteriaceae (Lindgren 1983). We see, therefore, that the process of "udaga" preparation could be in part attributable to LAB fermentation. "Udaga" demonstrated a higher level of safety than did other products; it can be considered safe for child feeding. "Makopa" had a high number of bacteria belonging to the family Enterobacteriaceae (Table 1); this indicated an unhygienic method of processing. The "makopa" also had a high number of moulds belonging to the genera *Rhizopus* and *Crysonilia*. These moulds are nontoxic and amylolytic. The starch is therefore hydrolyzed, and the viscosity of the gruels reduced (Mlingi 1984). Anderson (1944) reported that cassava products with red and black moulds were sweeter and easier to grind: these moulds are probably of the genera *Rhizopus* (whose spores are black) and *Crysonilia* (whose spores are scarlet); it is likely that the hydrolysis of the starch by these moulds makes the product sweeter. Protein enrichment of cassava using *Rhizopus oryzae* and *Rhizopus stolonifer* is also reported by Brook et al. (1969). This product has

Table 1. Distribution of microorganisms in three different types of fermented cassava products.

(A) Total Count and Enterobacteriaceae

Product	Number of studied products	pH range in product	Number of products with microorganism levels within given range (CFU/g)[a]								
			Total count (NA)[b]				Enterobacteriaceae (VRB + 1% glucose)[c]				
			10	10^{3-5}	10^{5-7}	10^{7-8}	10	10^{1-3}	10^{3-5}	10^{5-7}	10^{7-8}
"Udaga"	5	4.5-5.0	2	3			5				
	4	5.0-5.5		3	1		4				
	1	5.5-6.0			1		1				
"Makopa"	3	5.5-6.0		1	2					2	1
	6	6.0-7.0			3	3				4	2
	2	7.0-7.5			2					1	1
"Kivunde"	3	5.5-6.0		1	2			3			
	4	6.0-7.0		1	3			3	1		
	3	7.0-7.5			3				2	1	
Fresh cassava		6.1									

(continued)

Table 1. Continued.

(B) Bacillus and lactic acid bacteria

Product	Number of studied products	pH range in product	Number of products with microorganism levels within given range (CFU/g)[a]							
			Bacillus (BHI)[d]				Lactic acid bacteria (MRS)[e]			
			10^{3}	10^{3-4}	10^{4-5}	10^{5-6}	10^{3-4}	10^{4-5}	10^{5-6}	10^{6-7}
"Udaga"	5	4.5-5.0	2	3			1	1	3	
	4	5.0-5.5		4			1	3		
	1	5.5-6.0		1				1		
"Makopa"	3	5.5-6.0		1	1	1	2	1		
	6	6.0-7.0			4	2	3	3		
	2	7.0-7.5		1	1		2			
"Kivunde"	3	5.5-6.0		3			3			
	4	6.0-7.0	2	2			2	2		
	3	7.0-7.5	2		1		3			
Fresh cassava		6.1								

(continued)

Table 1. Concluded.

(C) Yeasts and moulds

Product	Number of studied products	pH range in product	Number of products with microorganism levels within given range (CFU/g)[a]						
			Yeasts (MEA)[f]			Moulds (MEA)[f]			
			10^4	10^5	10^6	10^3	10^{3-4}	10^{4-5}	10^{6-7}
"Udaga"	5	4.5-5.0	2	3		2	3		
	4	5.0-5.5	3	1		1	3		
	1	5.5-6.0	1				1		
"Makopa"	3	5.5-6.0	1	2				2	1
	6	6.0-7.0	3	3				3	3
	2	7.0-7.5	1	1				1	1
"Kivunde"	3	5.5-6.0	2	1		3			
	4	6.0-7.0		2	2	4			
	3	7.0-7.5	1	2		3			
Fresh cassava		6.1							

[a] CFU, colony-forming units.

[b] Nutrient Agar incubated at 28°C for 3-5 days.

[c] Violet Red Bile agar + 1% glucose incubated at 37°C for 1 day.

[d] Brain Heart Infusion agar incubated at 37°C for 2 days.

[e] de Mar, Rogosa, and Sharpe agar + 0.1 g/L primacin incubated at 28°C for 2 days.

[f] Malt Extract Agar + 30 mg penicillin and 30 mg streptomycin per litre incubated at 24°C for 5 days.

Table 2. Principal organic acids (%) in three different types of fermented products.

Type of product	Lactic acid	Acetic acid	Butyric acid	Propionic acid
"Udaga"	0.24 ± 0.08(9)	-	-	-
"Makopa"	0.04 ± 0.02(10)	0.02 ± 0.02(9)	-	-
"Kivunde"	0.03 ± 0.01(9)	0.03 ± 0.01(7)	0.02 ± 0.01(5)	0.01 ± 0.003(4)

Note: Values are means ± SD with the number of samples investigated in parentheses.

Table 3. Endotoxin levels in three different types of fermented products (mg/kg).

Type of product	Number of studied products	Number of products within endotoxin levels within a given range			
		3.0	3.0-6.0	6.0-9.0	9.0
"Udaga"	10	6	4	-	-
"Makopa"	11	-	2	7	2
"Kivunde"	10	2	5	2	1

a nutritional advantage in child feeding: the viscosity of the gruels is reduced, thus increasing nutrient-energy density; it has the disadvantage, however, of a poor level of safety.

The salient features of "kivunde" fermentation are not evident from Table 1. Numfor and Samke (1985) report that during the preparation of "fufu" (a fermented cassava product from Cameroon), the tubers are completely immersed in water, and the operation can be considered as liquid-state fermentation. Studies were therefore made of the liquid obtained by pressing the soaked cassava. "Kivunde" is prepared in the same way, but the dried product would not give much information on fermentation, except with regard to the safety of the food; this was found to be within acceptable limits. Endotoxin is produced by gram negative bacteria and is used as an indicator of the safety of the food.

Table 3 shows that "udaga" had low levels of endotoxin, indicating a higher level of safety than was shown by "makopa"; this was also evident from the microbial evaluation discussed earlier.

LAB found in these three products belong to the family Streptococceae. The isolated *Bacillus* spp. were identified as *Bacillus subtilis* and *Bacillus cereus*; the isolated yeasts were identified as *Saccharomyces cerevisiae* and *Candida* spp.

These fermentation processes are not controlled; the product may therefore vary from house to house. Although end products do not give a complete picture of fermentation, the present study provides some information on the basic process and on the safety of its products.

Conclusions

We see from the data that although "udaga" is safe for child feeding, more information is required on its nutritional quality. "Makopa" was found to have a high level of nontoxic moulds that were amylolytic. These moulds hydrolyze the starch and thus help to reduce the viscosity of the gruel prepared from "makopa" flour. At the same time, "makopa" had high levels of bacteria from the family Enterobacteriaceae. It is possible that these bacteria are destroyed on cooking; more information should, however, be obtained on the safety of the gruel prepared from this flour.

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DISCUSSION SUMMARY

For purposes of clarification, the chairperson provided the following definitions:

- Fermentation - a microbial process, resulting in desirable conversions;
- Souring - a microbial process, resulting in acidity caused by organic acids. Souring may be an objective of the fermentation. It can also be achieved through the addition of acidic fruit juices (such as lemon or lime juice), or plant products (such as tamarind or baobab);
- Germination - a plant process, resulting in the activation of plant hydrolytic enzymes, and in the conversion of polymers (starches and proteins) to smaller molecules. The excess enzymes can be utilized;
- Malting - the process of preparing malt by allowing cereal grain to germinate; and
- Malt - the product resulting from a drying of the germinated grain. This plant product is full of active enzymes.

This was followed by a discussion of the paper by Tomkins, Alnwick, and Haggerty, and of the food technologies advocated by them. It was suggested that we must determine whether these food technologies can help not only to increase the quantities of food consumed, but to improve the quality of that food; these are considerations both for the short and for the long term. We must also determine the safety of fermented products, with respect to contamination with microbial pathogens. Those factors must be considered that affect the choice of technology: mothers' work load, fuel shortage, etc. Finally, schemes must be developed for the promotion of these technologies.

A reduction in pathogenic diarrhea was found with the use of sour porridges. The group discussed three possible bacteriacidal mechanisms: pH, presence of volatile fatty acids, and antimicrobial substances. It was mentioned that some lactic acid producing bacteria do produce antibiotic-like substances: Lactobacillus bulgaricus, for example, produces the substance bulgarican. The importance was stressed of investigating not only the fate of the organisms, but also that of metabolites and toxins produced by microorganisms. As Tomkins noted, little exists in the literature regarding simple experiments to test whether bacteria live or die in a bowl of porridge.

Dr Brown spoke with regard to the collection of improved data on the digestibility of foods in humans. He stated that it was possible to obtain such data, but that the procedure was an expensive one, and was feasible only over a small range of foods. There is, therefore, a need for a consensus on the choice of foods and food technologies to be tested.

There were queries with regard to the reduction in lysine content reported to have occurred during the souring of "uji." Dr Mbugua accepted that inadequate measuring techniques may have indicated such a reduction where none existed. Lysine levels have been shown in other studies to be increased by fermentation.

Questions were raised concerning the acceptability of porridges without sugar - an issue dealt with in the paper by Keregero and Kurwijila. It was suggested that although the children who were given the sour porridge did not refuse it, neither did they express a preference for it.

A question was also raised concerning the increase in protein reported by Mlingi to follow cassava fermentation. It was argued that substantial increases in protein could be obtained only if a nitrogen substrate such as urea were added for the formation of mycellular proteins; nitrogen, it was stated, has never been shown to enter foodstuffs from the air via microorganisms.

The chairperson then decided to clarify issues relating to definitions of energy density and viscosity. The following example was used:

	Fresh porridge	**Fermented porridge**	**Fermented porridge with the addition of more flour**
Dry weight (g)	6	6	8
Viscosity (cP)	100	80	100
Energy density (kcal/g)	25	25	33

[Editors note: In the first column, an unfermented porridge is seen to have an energy density of 25 kcal/g and a viscosity of 100 cP. Upon fermentation, certain changes in the structure of the starch granules, and some hydrolysis of starch to soluble sugars takes place, resulting in a decrease in viscosity to 80 cps units (second column). Note, however, that the fermentation process has done nothing to increase the quantity of food in the porridge, and therefore the energy density remains the same as before (25 kcal/g) although the porridge now appears a little thinner and "less bulky." In the final column, an example is given of a porridge to which more flour has been added, 8 g instead of 6. Fermentation has then been used to reduce the viscosity of this porridge to 100 cP. This will result in a porridge which has the same viscosity (and bulkiness) as the fresh porridge, but a higher energy density (33 kcal/g instead of 25). Although it is often said that fermentation (or the addition of germinated grain or "power flour") increases the energy density of a porridge, this is not strictly correct. The increase in energy density is achieved by adding more flour, and the viscosity of this thicker porridge is then reduced by fermentation or an enzymatic process. The question of the definition of dietary bulk is further discussed in the paper by Svanberg, this volume.]

The discussion addressed the question of reduction in food intake during illness. There are two reasons for a reduced food intake: true physiological anorexia, and cultural patterns of food withholding. Liquids may be easier to consume during illness. It is important, when discussing the effects of an illness on energy intake, to identify the illness concerned. In Dr Brown's work, diarrheal disease alone was not found to be associated with any reduction in energy intake; such reductions were, however, found to a significant degree with fever, or with fever and diarrhea.

The group discussed the issue of force feeding. Although this practice has been discouraged, its use was reported in Nigeria (by Dr Brown) and in Kenya. Some view force feeding as a useful way of introducing energy into a child, in circumstances that offer only a bulky staple porridge. The practice was formerly carried out by experienced, elderly women; their skills have not, however, been passed on to the present generation of mothers. The resultant inadequacy in technique causes aspiration of food and can be fatal. Studies are currently underway to assess the situation. A particular problem is the aspiration of foods containing saturated fats; this is known to cause "lipid pneumonia."

The group then went on to note the importance of determining the pH and buffering capacity of sour porridge. (This information was not provided in Dr Brown's study.)

With regard to the paper by Hakimjee and Lindgren, it was suggested that their determinations had been made on the uncooked product. In many cases, the product would be cooked before consumption; the significance of the findings would thus be modified, with respect to the risk of diarrhea.

Also questioned was the nontoxigenicity of the fungi used in preparing certain cassava foods. Ms Hakimjee stated that no citings had been found in the literature to indicate that Rhizobious fungi were harmful.

With respect to the paper by Ayebo and Mutasa, there was some discussion as to the temperature at which household fermentations take place. It was agreed that even were the container to be wrapped in a blanket and left in a warm place, the temperature would seldom rise above 30°C.

It was pointed out that the malt added to the porridges in Dr Ayebo's experiments provided a bacterial inoculum as well as carbohydrate and enzymes. The ability of sorghum to produce malt and flavour depends on the variety of the sorghum; Dr Ayebo had used only the common red variety of sorghum. The absence was noted of any indication of variance in the figures provided in Table 4.

In testing the acceptability of new food products, it was believed to be of crucial importance to have members of a taste panel taken from the "target population"; these people would, after all, be the ultimate consumers of the product.

The question was raised as to whether it was the pH, the buffering capacity, or the titrable acidity that was important in protecting the food against contamination.

Dr Nout provided the following synthesis of the discussion:

FERMENTATION OF CHILDREN'S FOOD

Benefits	**Costs**
Improved taste and eating properties (organoleptic)	Energy needed for growth and maintenance of microorganisms
Improvement in nutrient availability	Nutrient loss
Food perservation and safety	Process spillage and losses
Detoxification	

It was pointed out that cultural and economic acceptability should also be considered in such a synthesis.

The group discussed the benefits conferred by the sour taste of fermented porridge. It was generally agreed that such a taste was desirable. Children in a hospital in Zimbabwe were said to have consumed more of the sour porridge than of the fresh, unsour variety. Sick children especially took more of the sour product. In Uganda, the sour taste of porridges was said to have nonnauseating qualities. In Lesotho, mothers likened the sour taste of fermented porridge to that of oranges or lemons, and said that it helped sick children to eat. The final taste of the product was said to relate to the buffering capacity as well as to the pH: if the buffering capacity is poor, a lightly soured porridge may have an unacceptable taste.

The importance of weaning foods as a primary source of pathogenic bacteria in a child's environment was questioned: it was pointed out that weaning-age children are crawling and are therefore exposed to many other sources of infection. In reply, it was stated that it is not simply a matter of exposure to bacterial pathogens, but of the size of an infectious dose. Food permits easy and rapid multiplication of microorganisms, and therefore provides a greater risk than other sources of bacteria. It was also deemed important to consider the etiology of diarrhea, and to investigate the effects of souring on specific etiologic agents.

With reference to the table of costs and benefits suggested by Dr Nout, the question was raised as to whether we should restrict ourselves to bacteria that fortuitously present themselves. Could bacteria not be developed or engineered with specific desirable properties? Bacteria have been developed to prevent the destruction of strawberries by ice; could similar technology not be harnessed to solve problems of greater human significance?

The question of process losses and spillages was discussed. Nigerian "ogi" production was given as an example of a particularly inefficient process. The final product is little more than maize starch, from which all soluble nutrients have been washed. A more efficient process - one that is dry - has now been developed for the production of "ogi."

Session IV

Food Contamination and Lactic Fermentation

WEANING FOOD HYGIENE IN KIAMBU, KENYA

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Abstract *Food contamination has been associated with an increased intake of pathogens and with the occurrence of diarrhea in infants. A study was carried out in Kiambu District in Kenya; the objective of this study was to identify those weaning practices that carry a high risk of fecal contamination of infant food, but that could be modified by an intervention program. The presence, just before consumption, of Escherichia coli in the foods was taken as the indicator for fecal contamination. From food prepared for infants less than 1 year of age, 738 samples were collected and examined for the presence of E. coli. Methods of preparation, of storage, and of handling were also recorded. The results suggest a low level of contamination of infant foods. It is likely that this is due to appropriate food handling techniques and to the fact that most foods were cooked for relatively long periods at medium or high temperatures.*

Weaning food hygiene can be defined as the handling, preparation, and storage of weaning food in such a way that the intake of pathogens by the child is decreased. Esrey et al. (1985) reviewed the literature on practices in developing countries that are associated with increased contamination. Stanton and Clemens (1987) showed an association between the frequency of handwashing before preparation of food and incidence of diarrheal disease. In a community-based study, Black et al. (1982) showed an association between food contamination with Escherichia coli and the incidence of enterotoxigenic E. coli diarrhea. Several practices were found to be associated with fecal contamination that has occurred just before the food is eaten. Barrell and Rowland (1979) found in the Gambia that the level of pathogens increased during the storage of specific food items. Black et al. (1982) found in Bangladesh that food contamination at the household level increased with higher temperatures and with longer periods of storage.

In this paper, we use fecal contamination (taking place just before consumption) as a measure for the intake of pathogens; the risk of food contamination will be identified by a measuring of the pathogenic load.

The objective of the study was to identify those weaning practices that carry a high risk of fecal contamination of infant food, but that could be modified by an intervention program. It was deemed necessary to determine

- The level of fecal contamination in common weaning foods;
- The extent to which cooking temperature and time influence fecal contamination of food; and
- The extent to which fecal contamination is influenced by the state of the utensils or by the identity of the person handling the infant food.

The study area is located 2 km from Nairobi, the capital of Kenya. It is a semi-arid rural area at an altitude of 1500-2000 m, with an annual rainfall of 600-700 mm from March to June and October to November. The population is homogeneous in terms of social structure. People live in settlement villages, each family holding between 0.5 and 1 acre (1 acre = 0.405 ha) where subsistence farming is practiced and a few animals are kept. There are no industries in the area; people work on the surrounding farms or in Nairobi. An average of six people live together in a house. The population density varies from 200 to 600/km^2. Water is available from one or two boreholes in each village and is distributed in donkey carts. The average use of water is 40 L in 50% of the families, 60-80 L in 40%, and 100-160 in 10%.

Methodology and Results

About 60 households were observed every other month, from September 1986 to May 1987. A fieldworker trained in observation methods remained in the house from 0700 to 1800, watching the caretaker's handling of the infant's food and drink. These observations covered preparation (cooking temperatures, duration of working, and type of ingredients), storage time, use of utensils, and identity of the person feeding the infant.

Samples were taken by the mother from food that the child had eaten at night; these samples were stored in a cool box (at around 4°C) until the following morning, when they were collected and transported between icepacks to the central laboratory in Nairobi. All samples were taken just before eating, and from the same utensil as was used for the feed. Although the 738 samples were examined for aerobic and enterobacteriaceae count (for an indication of the general level of hygiene), it was, for the purposes of this paper, the presence of *E. coli* that was taken as the indicator for fecal contamination.

Table 1 shows contamination of food that had been freshly prepared and that of food left over from a previous meal. Also included in the testing were "night samples": the researchers wished to determine whether the caretakers tended to be more careful in the presence of the fieldworkers. The table indicates that the percentage of contaminated infant food was relatively low (approximately 14%). When the fieldworkers were present, fresh food was prepared for the infants about two-thirds of the time; only 10.7% of the samples from

Table 1. Food samples contaminated, according to freshness and type of food (% in parentheses).

	E. coli present	E. coli absent	Total
Freshly prepared	38 (10.7)	318	356
Leftover	34 (18.7)	148	182
Night sample	34 (17)	166	200
Total	106 (14.4)	632	738
Food type			
Tea	4 (20)	16	20
Porridge	12 (11.2)	95	107
Cooked cereal	61 (20.1)	242	303
Water	15 (9.8)	138	153
Milk	14 (10.4)	121	135
Total	106 (14.6)	612	718

these freshly prepared foods were contaminated. Contamination was found more often in samples of leftover food.

Table 1 also shows contamination according to type of food; the contamination in question occurred just before the food was consumed. Table 1 shows that among the various food items consumed, cooked cereals (the food most often used) had the heaviest contamination. Table 2 shows the various cooking temperatures and times of the food items in Table 1. Of the total number of food samples collected, about one-third were cooked for more than 1 h at temperatures of more than 70°C. Ten percent of the food samples were cooked for less than 5 min at temperatures under 30°C. About 60% of the food was cooked at moderate temperatures for a relatively long period.

Table 3 shows contamination according to cooking time and temperature. The contamination with which we are concerned here

Table 2. Number and proportion of food samples according to cooking temperature and time.

Cooking time (min)	Cooking temperature (°C)					
	≤30	31-39	50-69	70-79	≥80	Total
≤5	64	51	69	18	41	243
6-15	4	23	29	15	36	107
16-30	2	3	2	15	35	57
31-59	0	1	9	18	75	103
≥60	0	0	2	3	223	228
Total	70	78	111	69	410	738

Table 3. Food samples contaminated according to cooking temperature and time (% in parentheses).

	E. coli present	E. coli absent	Total
Cooking temperature (°C)			
≤ 30	14 (20.0)	56	70
31-49	7 (9.0)	71	78
50-69	20 (18.0)	91	111
≥ 70	65 (13.5)	414	479
Total	106 (14.4)	632	738
Cooking time (min)			
≤ 5	37 (15.3)	205	242
6-30	22 (13.6)	140	162
31-59	10 (9.7)	93	103
≥ 60	37 (16.0)	194	231
Total	106 (14.4)	632	738

Note: $x^2 = 2.58$, 3 df, $p = 0.46$.

occurred immediately after preparation. Table 3 indicates that neither time nor temperature influenced the levels of contamination. It should, however, be noted that these food samples were not collected immediately after preparation, but just before the food was to be eaten; various handling procedures, such as cooling and storing, had therefore taken place.

Table 4 shows the length of time between the preparation or warming of the food and its consumption. Where an observer was present, the infant was fed almost immediately after the food was prepared (Rowland et al. 1987); this was the case over 75% of the time. About 16% of the food was eaten within 12 h of preparation. Only 5% was eaten over a further 12-h period. We see, therefore, that although this food becomes more contaminated the longer it is stored, the quantities of food stored for long periods are fortunately very small.

Table 4. Food samples contaminated according to duration of storage (% in parentheses).

Duration of storage	E. coli present	E. coli absent	Total
Eaten immediately	53 (12.6)	367	420
<12 hours	14 (15.9)	74	88
>12 hours	5 (17.9)	23	28
Night sample	34 (16.8)	168	202
Total	106 (14.4)	632	738

Note: $x^2 = 2.49$, 3 df, $p = 0.48$.

Table 5. Food samples contaminated according to method of feeding (% in parentheses).

Method of feeding	E. coli present	E. coli absent	Total
Bottle	12 (14.1)	73	85
Cup and spoon	53 (12.8)	361	414
Hands	7 (18.4)	31	38
Night sample	34 (16.9)	167	201
Total	106 (14.4)	632	738

Note: $X^2 = 2.39$, 2 df, $p = 0.49$.

Table 6. Food samples contaminated according to identity of person feeding the infant (% in parentheses).

Person feeding	E. coli present	E. coli absent	Total
Mother	57 (13.2)	374	431
Other	15 (14.2)	91	106
Night sample	34 (16.9)	167	201
Total	106 (14.4)	632	738

Note: $X^2 = 3.59$, 2df, $p = 0.16$.

Table 5 shows contamination according to method of feeding. It must be noted that the food was served in the utensils but not stored in them. Excluding the night samples, taken when no observer was present, about 75% of the infants were fed from a cup and spoon, 16% bottle fed, and another 7% hand fed.

Table 6 shows contamination according to identity of the person feeding the infant. We see that in most cases (about 75% of the time during the observation period), it was the mothers who fed their infants. Approximately the same number of samples were collected from feeds given by the mother as from those given by other people ($p = 0.16$); in the latter instances, however, the levels of contamination are noticeably higher.

Conclusions

The study showed that levels of contamination of infant foods are relatively low in Kiambu District. This could be due to the following factors: over 75% of the time, the food is eaten almost immediately after being prepared; during the weaning period, mothers take direct responsibility for feeding their infants; and in most cases, the food is cooked for relatively long periods, at medium or high temperatures. (This has been said by food hygienists to reduce the inoculation dose.) Sampling of the food immediately after cooking will therefore give different results, depending on cooking time and temperature.

Where higher levels of contamination were in evidence, the study shows that the handling of the food after preparation had had some influence: it was observed, for example, that when food was cooked at high temperatures, the mothers would add either cold milk or leftovers to cool it - a process that could have led to contamination. Of all the weaning foods, cooked cereals were most often used and were most often contaminated. It should be mentioned, however, that a diarrhea surveillance survey conducted in this district showed that the incidence of diarrhea was 0.54 attacks/child per year among infants under 6 months of age, and 1.66 among children aged 6 months to 1 year; these rates appear very low when compared with those in other parts of Kenya.

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FECAL CONTAMINATION OF WEANING FOODS IN ZIMBABWE

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Abstract *A total of 222 weaning food samples were collected from the homes of young children with diarrhea, and from age-matched controls. The commonest foods collected from the homes were porridge, "sadza" (thick porridge), vegetables, and "mahewu," a semisweet cereal gruel. The food samples were cultured for* *Escherichia coli* *and for certain bacterial enteric pathogens. Seventeen per cent of the food samples were contaminated with* *E. coli;* *bacterial pathogens were isolated in 3% of the samples. Most of the infant foods had been stored for periods of 13-24 h; with the exception of vegetables, however, no relationship was found between storage time and contamination with* *E. coli.* *A lower percentage of bacterial contamination was found in vegetables that had been stored in cooking pots; otherwise, no relationship was found between contamination with* *E. coli* *and the utensils used for storage.*

Diarrheal disease is one of the major problems affecting young children in developing countries. In some developing countries, infant foods and drinking water are often fecally contaminated, and are therefore potential sources of diarrheal illness. In Zimbabwe, the first supplementary food given to infants from the age of about 6 months is porridge; this is in turn supplemented with adult foods consisting mainly of "sadza" (thick maize meal porridge), served with vegetables and meat. Leftovers from the evening meal are usually consumed by young children the following morning.

The results presented in this paper were obtained from a study, conducted at two clinics in a farming community, on the relationship between weaning foods and drinking water and the incidence of diarrhea in 5-year old children. Stool specimens and samples of food and drinking water were collected from children with diarrhea, and from age-matched controls. These specimens and samples were then examined for certain bacterial enteric pathogens. The food and water samples were also examined for Escherichia coli (an indicator for fecal contamination).

Contamination of All Foods

Only those results pertaining to weaning foods are presented in this paper. The types of food examined, and their levels of contamination with *E. coli*, are shown in Table 1. Most of the foods collected from the homes were vegetables (rape, cabbage, indigenous cultivated plants), "sadza" (a thick porridge), and "mahewu" (a fermented, nonalcoholic, sour cereal gruel). Twenty-one per cent of the vegetables, 18% of the "mahewu," 14% of the "sadza," and 9% of the porridge samples showed the presence of *E. coli*. This pathogen was shown, however, to be present in a very low percentage of the meat samples (beef, chicken, and fish).

Table 2 shows the level of contamination in relation to storage time. Most of the foods were stored for periods of 13-24 h; very few foods were stored for more than 24 h. There was no relationship found between storage time and contamination with *E. coli*.

Table 3 shows the level of *E. coli* contamination in relation to utensils used for storage. No great difference in levels of contamination was found with various containers; this applies also to the question of whether or not the containers were covered. *E. coli* was present in 17% of the leftover foods and in 15% of foods that were not leftovers.

Contamination of the Most Common Foods

Table 4 shows the levels of bacterial contamination for those foods most commonly found in the the home (porridge, "sadza," "mahewu," and vegetables), in relation to storage time and to storage

Table 1. Level of contamination with *E. coli* in foods consumed by young children.

	Number of specimens contaminated (in counts per mL/g of food)						Samples contaminated (%)
	0	10^0-10^1	10^2-10^3	10^4-10^5	10^6-10^7	Total	
Vegetables	34	-	5	3	1	43	20.9
"Mahewu"	31	-	2	4	1	38	18.4
Porridge	32	-	1	-	2	35	8.6
"Sadza"	18	-	-	1	2	21	14.3
Meat	15	-	1	-	-	16	6.2
Sugar salt solution (ORS)	9	-	-	3	2	14	35.7
Pumpkins	11	1	2	-	-	14	21.4
Bread	10	-	-	-	-	10	0
Tea	9	-	-	-	-	9	0
Milk	3	-	1	1	2	7	57.1
Potatoes	5	-	-	-	-	5	0
Green mealies	1	-	1	1	-	3	66.7
"Fanta"	3	-	-	-	-	3	0
Rice	2	-	-	-	-	2	0
Boiled corn	1	-	-	-	1	2	50.0
Total	184	1	13	13	11	222	17.1

Table 2. Level of contamination with E. coli in weaning foods, in relation to storage time.

Storage time (hours)	Number of specimens contaminated (in counts per mL/g of food)						Samples contaminated (%)
	0	10^0-10^1	10^2-10^3	10^4-10^5	10^6-10^7	Total	
0-12	10	1	3	3	2	19	47.4
13-24	93	1	10	10	7	121	23.1
25-36	2	-	-	-	1	3	33.3
37-48	5	-	-	-	-	5	0
>48	1	-	-	-	1	2	50.0

Table 3. Level of contamination with E. coli in weaning foods, in relation to type of storage utensil.

Type of storage container	Number of specimens contaminated (in counts per mL/g of food)						Samples contaminated (%)
	0	10^0-10^1	10^2-10^3	10^4-10^5	10^6-10^7	Total	
Cooking pot	39	-	3	2	2	46	15.2
Bowl	40	-	6	3	3	52	23.1
Tin can or plastic container	18	1	1	3	1	24	25.0
Cup	14	-	1	1	1	17	17.6
Bottle	12	-	-	3	3	18	33.3
Clay pot	7	-	3	-	-	10	36.0
Plasitc bag	6	1	-	1	-	7	25.0
Other	2	-	-	-	-	2	0
Covered	120	1	9	1	5	135	11.1
Not covered	53	2	4	2	5	66	19.7
Containing leftovers	94	1	8	3	7	113	16.8
Containing food, not leftovers	33	1	2	3	-	39	15.4

utensil. Most of the porridge given to infants was stored for less than 12 h; the cooking pot was the container most commonly used. There was slightly more contamination of porridge stored in other containers than of that stored in the cooking pots (16 and 13%, respectively). Most of the "mahewu" was stored for 13-24 h, and a variety of containers were used. From this table, it can be seen that most of the vegetables were stored for periods of 13-24 h, and that an increase in contamination with E. coli accompanied an increase in storage time. As was the case with porridge, vegetables that had been stored in cooking pots showed lower levels of contamination than did vegetables stored in bowls. Most of the "sadza" had been stored in bowls for periods of up to 24 h.

Table 4. Level of contamination with E. coli in porridge, "mahewu," vegetables, and "sadza," in relation to storage time and to storage utensil.

	Number of specimens contaminated (in counts per mL/g of food)						Samples contaminated (%)
	0	10^0-10^1	10^2-10^3	10^4-10^5	10^6-10^7	Total	
Porridge							
Storage time							
0-12	27	-	1	-	2	30	10.0
13-24	3	-	-	-	1	4	25.0
25-36	1	-	-	-	-	1	0
Storage utensil							
Cooking pot	14	-	1	-	1	16	12.5
Bowl	8	-	-	-	-	8	0
Cup	8	-	-	-	1	9	11.1
Other	1	-	-	-	1	2	50.0
"Mahewu"							
Storage time							
0-12	1	-	-	1	1	3	66.6
13-24	25	-	3	2	1	31	19.4
25-36	2	-	-	-	-	2	0
37-48	3	-	-	-	-	3	0
Storage utensil							
Cooking pot	9	-	-	1	-	10	10.0
Tin can/plastic container	13	-	-	2	1	16	18.7
Cup	4	-	-	1	-	5	20.0
Clay pot	5	-	2	-	-	7	28.6
Vegetables							
Storage time							
0-12	18	-	1	-	-	19	5.3
13-24	16	-	4	3	1	24	33.3
Storage utensil							
Cooking pot	24	-	3	-	-	27	11.1
Bowl	10	-	2	3	1	17	35.3
"Sadza"							
Storage time							
0-12	5	-	-	1	-	6	16.7
13-24	10	-	-	-	2	12	16.7
Storage utensil							
Cooking pot	1	-	-	-	-	1	0
Bowl	14	-	-	1	2	17	17.6

Isolated Enteric Pathogens

All the food samples collected from the homes were cultured for the following bacterial pathogens: *Salmonella* sp., *Shigella* sp., *Campylobacter* sp., *Aeromonas* sp., enteropathogenic *E. coli*, and enterotoxigenic *E. coli*. Seven (3%) of the 222 food samples cultured had bacterial pathogens; enteropathogenic *E. coli* was the commonest pathogen isolated. The serotypes of enteropathogenic *E. coli* isolated in the foods were similar to those isolated in the stool specimens of the children. *Campylobacter* sp., the commonest bacterial pathogen isolated in the stool specimens, was not isolated in any of the food samples collected from the homes of the children.

Because the data are still being analyzed, the results of investigations into water contamination (the most probable source of contamination of food and of containers) are not given.

FORMULATION AND MICROBIOLOGICAL SAFETY OF CEREAL-BASED WEANING FOODS

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Abstract *The appropriateness of a composite weaning food can be determined by a consideration of the following factors: the target group - its energy and protein requirements, and its daily food intake capacity; the use and chemical composition of locally produced ingredients; and the acceptability of the food, in terms of palatability and consistency. Examples are given for the calculation of mixtures of white sorghum flour, pigeon pea meal, and groundnut meal, with vegetable oil or sorghum malt added to adjust the viscosity. This paper presents the microbiological properties of sorghum porridge and of sorghum composite mixtures. In particular, it examines the effect of controlled lactic fermentation on the microbiological stability of the final cooked products. Controlled lactic fermentation of a sorghum base achieved pH 3.80 after 12 h at 30°C, and yielded porridges in which added Salmonella typhimurium was destroyed during storage experiments at 30°C for 24 h. Similar effects could be obtained in sorghum composite mixes with pigeon pea and groundnut meals. It is concluded that lactic fermentation has the potential to be an excellent protective treatment for cereal-based composite foods.*

It has recently been estimated by the United Nations Children's Fund that over 14 million infants and children under 5 years of age die annually in the tropical regions of the world (UNICEF 1987). One of the major causes is a watery diarrhea - the result of infection by pathogenic microorganisms. Although other infections such as Ascaris roundworm are also regarded as detrimental to nutritional status (Stephenson et al. 1980), the occurrence of acute watery diarrhea is a major cause of dehydration and of poor absorption of nutrients from the diet (NRC 1985); this is estimated to cause an annual mortality of 5 million infants and children (Evans 1986). We must also include the inadequate intake of macronutrients and of energy that results in protein energy malnutrition (PEM), with an estimated mortality of 3 million per year (Evans 1986).

Microorganisms associated with diarrheal diseases are found particularly in three families of bacteria: the Enterobacteriaceae, among which the genera Escherichia, Salmonella, Shigella, and Yersinia are well known as causative agents of food-borne gastroenteritis; the Vibrionaceae, associated with the cholera diseases, and the Spirillaceae, among which the genus Campylobacter is increasingly regarded as a potential food infection-causing bacterium. Although any human risks contracting a food-borne infection from the consumption of contaminated food or water, epidemiological evidence shows that the people particularly at risk are those who are weak or in a poor nutritional condition (Chen 1983). Such persons are mainly infants, young children, the sick, and the elderly. In the fight against malnutrition, we should therefore focus on a combination of improved intake of essential nutrients and protection against potentially harmful microorganisms.

In this paper, we attempt to deal with both aspects from the perspective of infant and young child feeding, particularly during the weaning period. The concept of cereal-based composite weaning foods will be discussed. This is a matter of particular interest at the Department of Human Nutrition of the Agricultural University, Wageningen, The Netherlands, and at the International Courses in Food Science and Nutrition of the International Agricultural Centre, Wageningen, The Netherlands, where the concept has been tested by the practical work of several project groups of foreign course participants. The microbiological properties of cereal-based composite mixes will then be discussed, giving an idea of some of the research taking place at the Department of Food Science of the Agricultural University. Recently, Alnwick (1986) emphasized the need for data on the preservation by fermentation of sorghum- and other cereal-based porridges. The aim of this paper is to provide an insight into the effect of lactic fermentation on the microbiological safety of such products.

Weaning Foods in Africa

Cereal-based porridges ("uji," "ogi," etc.) are commonly used as weaning foods. There are three possible ways of preparing these porridges: (a) fresh flour + water → boil → consume ("sweet" porridge); (b) fresh flour + water → ferment overnight → boil → consume (sour porridge); and (c) fresh flour + water → boil → ferment → consume (sour porridge). Systems (a) and (b) are the most commonly used; system (c) is used only occasionally. The method of fermentation used in (b) is mostly of an uncontrolled and mixed character. Lactic acid producing bacteria are responsible for the fermentation.

Fermentation of cereals can have the following advantages:

- **Organoleptic:** Because of the production of lactic, acetic, and butyric acids (Banigo and Muller 1972) and of other metabolites, an acceptable flavour is developed.

- **Viscosity:** Fermented porridges cook more easily and have a lower viscosity (Mbugua 1987); higher levels of dry matter can therefore be achieved, and acceptable viscosity maintained in the final product.

- **Nutritional:** During 24 h-fermentation, some vitamins, such as thiamine, riboflavin, and niacin, are synthesized (El Tinay 1978); the splitting of proteins results in the increase of free amino acids, including lysine, methionine (Fernandes et al. 1987), and tryptophan (Mbugua 1987); fermentation could also reduce the content of antinutritional components such as tannins and phytic acid (Muller 1981), and possibly of trypsin inhibitors; interestingly, it has been found as well that in aflatoxin-contaminated sorghum, 63% of aflatoxin B1 was removed during the fermentation of "ogi" (Dada and Muller 1983).

- **Preservative effect:** Because of the acidity and presence of organic acids in lactic fermentation, the growth of several pathogenic and spoilage-causing bacteria is inhibited.

This last aspect might be particularly interesting, in view of the fact that the porridge comes easily into contact with pathogenic microorganisms from water or equipment, or through handling, even with hygienic preparation under household conditions. Also of interest is the common practice of keeping leftovers; storage periods may be as long as 6-8 h at room temperature (25-30°C). In the Gambia, it was found that nonfermented traditional weaning foods contained high levels of pathogens after such storage (Rowland et al. 1978).

The potential advantages of lactic fermentation have been reported by Alnwick (1986). Our research was partly inspired by his recommendations for research into the capacity of fermented porridges to protect the consumer against pathogenic microorganisms. Although fermentation offers many interesting nutritional and safety benefits, we should accept the fact that the activity of microorganisms requires energy and nutrients; as a consequence, fermentation will, to some extent, decrease the total amount of energy in the food (Muller 1981); losses will also be caused in protein (El Tinay 1978) and in vitamins. It therefore remains necessary to find processes that reduce such losses as much as possible.

Composite Weaning Foods

The weaning period is that in which the infant progresses "gradually" from exclusive breastfeeding to consumption of the full adult diet. The appropriateness of a weaning food can be determined by a consideration of the following factors: the target group - its particular nutritive requirements and its intake capacity; the ingredients and their nutritive value; and the physical, organoleptic, and cultural acceptability of the food as prepared.

Infants require complementary feeding from around the age of 4-6 months (Waterlow 1981). A gradually increasing provision of complementary food causes a concomitant reduction in the child's dependence on breast milk; this reduction continues until the child can fulfill all his or her nutritional needs with an adult diet. Apart from nutritional concerns, the development of certain physical skills (the chewing and swallowing of relatively large quantities of solid food) determines the type of food that is appropriate at a particular age; the maximally problematic age is about 9-12 months, when an already considerable nutritional demand coincides with a still limited ability in masticating and in swallowing, and with a limited stomach capacity (Waterlow and Payne 1975). Studies have been conducted that establish standards for energy and protein requirements (Klaver 1985): if a food or meal has a net protein content of 7.8% of the total energy value, this food or meal will satisfy the protein needs of almost all children aged 9-12 months, provided enough of the food is eaten to satisfy the energy requirements. Energy intake, therefore, assumes predominant importance; this coincides with current thinking about the etiology and prevention of PEM.

The main energy component in weaning foods and diets is starch from the cereal or tuber used as the culturally acceptable staple food. The swelling of starch during cooking causes a significant increase in the volume of the food; given the constraints of feeding frequency and stomach capacity, it therefore becomes impracticable to rely on this food to cover all the energy needs of the child (Nicol 1971). Increasing the dry matter content will increase the consistency and thus give a product that is unacceptable to the child who cannot yet consume solid foods. The following are two technologically simpler methods for overcoming this problem: first, the addition of edible oil or fat (Dearden et al. 1980); and second, the use of cereal malt (Brandtzaeg et al. 1981). Both techniques result in a lower viscosity and therefore permit the consumption of a meal with a higher nutritional content per unit of volume. Allowing for the constraint of feeding frequency, higher energy intakes are thus achieved.

The constraint of feeding frequency is, at least in part, culturally determined. Unless the possibilities for food preservation have been considered, it will, in many instances, remain unrealistic to advise more frequent feeding. We consider in this paper the usefulness of simple fermentation technologies for the preparation of nutritionally adequate weaning foods that can be preserved safely and therefore kept ready for more frequent feeding.

Formula Calculation

Ingredients used in this study were white sorghum flour, ground pigeon pea, groundnut meal, groundnut oil, and malt made from white sorghum grain. The approximate composition of these ingredients was obtained from food tables (Platt 1962; FAO 1970, 1986); energy, protein, and dry matter were determined by laboratory methods. Energy contents were calculated, taking digestibility into account for a determination of metabolizable energy. Optimal proportions of ingredients were determined by principles of complementarity among amino acid patterns (Klaver 1985). Desirable quantities of ingredients were derived from recommendations of energy intakes. The groundnut oil and sorghum malt were added to the mixtures in quantities that would cause a spread of 5-6 cm diameter at 45°C within 1 min from a cylindrical (2.5 cm diameter; 7 cm height) starting position, using the Adams Consistometer (Szczesniak 1972).

The compositions of the mixes are given in Table 1, together with their nutritive values for energy and protein. The energy density is

Table 1. **Composition and nutritive value of sorghum-based composite mixes.**

Ingredient	S-PP-O-M[a]	S-PP-M[a]	S-GN-O[a]	S-GN-M[a]
Sorghum flour (%)	11.6	16.9	6.6	10.0
Pigeon pea meal (%)	4.3	2.8	-	-
Groundnut meal (%)	-	-	8.0	7.7
Groundnut oil (%)	2.4	-	0.8	-
Sorghum malt (%)	0.2	1.2	-	0.2
Water (%)	81.5	79.1	84.6	82.1
Energy (kcal/100 mL)	83	79	77	82
Net usable protein g/100 mL)	1.6	1.5	1.5	1.6

[a] S, sorghum; PP, pigeon pea; GN, groundnut; O, groundnut oil; M, sorghum malt.

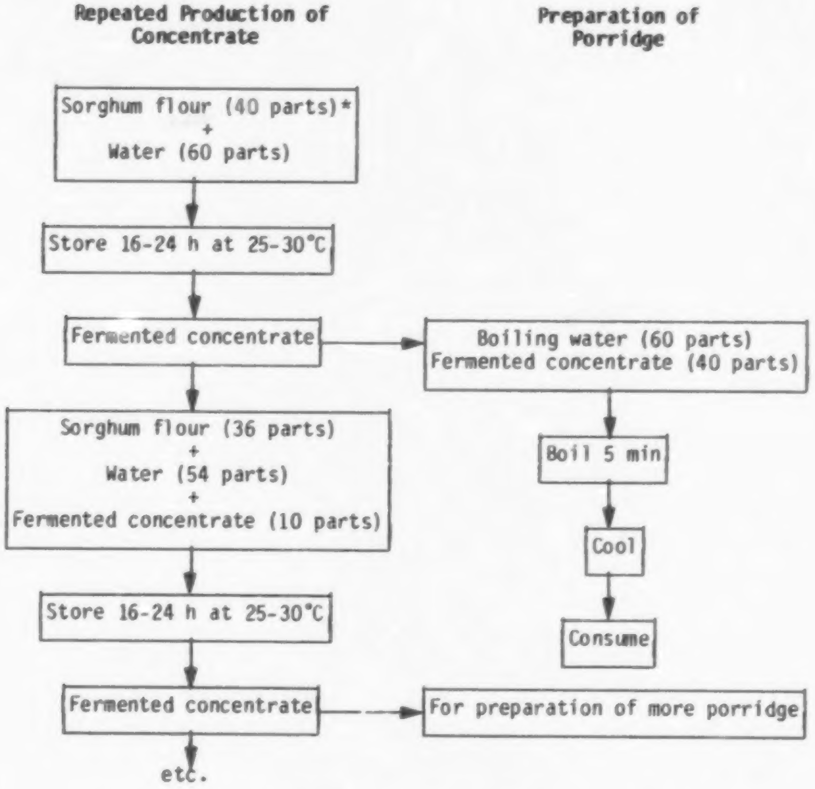
Repeated Production of Concentrate
Preparation of Porridge
Sorghum flour (40 parts)*
+
Water (60 parts)
Store 16-24 h at 25-30°C
Fermented concentrate
Boiling water (60 parts)
Fermented concentrate (40 parts)
Sorghum flour (36 parts)
+
Water (54 parts)
+
Fermented concentrate (10 parts)
Boil 5 min
Cool
Store 16-24 h at 25-30°C
Consume
Fermented concentrate
For preparation of more porridge
etc.

Fig. 1. **Fermentation of sorghum flour and preparation of porridge. *, parts by weight.**

around 80 kcal/100 mL. An infant of 9 months has a stomach capacity of about 275 mL (Tomkins 1986); one feeding therefore allows an energy intake of 220 kcal, and a utilizable protein intake of 4.3 g.

Controlled Lactic Fermentation of Sorghum Flour

Figure 1 presents a simple technique for controlled lactic fermentation; this technique can be carried out at the household level. Each day, a small quantity of the fermented concentrate is used as a starter for the next fermentation. The remainder is used for porridge preparation. This is an established method in traditional fermentation technology called "back-slopping." If we continue in this way by using approximately 3-10% of the previous batch as a starter for the next fermentation, a gradual selection of microorganisms will take place, favouring those organisms that grow best at low pH and under near-anaerobic conditions.

The effect of this fermentation procedure on the acidity is summarized in Table 2. After three repetitions of back-slopping, we see that the pH is considerably lower (3.8-4.0) than that of fresh flour or of a mixture fermented only once; the acidity (caused mainly by lactic and acetic acids) is higher (about 0.85%, calculated as lactic acid).

This stabilization of the souring by back-slopping is presented in Fig. 2. Our earlier experiences with the stabilized souring of soybeans (Nout et al. 1987) has shown that the back-slopping method is reliable over long periods, and that occasional interruptions (caused, for example, by public holidays) do not necessarily influence its dependability. Table 3 shows that after a few repetitions of back-slopping, the composition of the microflora undergoes a significant shift toward the lactic acid producing bacteria; some yeasts will also remain present. On the other hand, Enterobacteriaceae gradually disappear, as will the aerobic epiphytic flora of sorghum. (This latter includes, for example, moulds and bacteria of the genus Bacillus, that can cause spoilage or food poisoning or both.)

The described method of back-slopping offers a predictable and rapid lactic fermentation and can be carried out under simple household conditions. Although we refer to it here as a "controlled lactic fermentation," there is no requirement for the maintenance and handling of microbial pure cultures; rather, the principle of natural selection is employed. An alternative method of lactic fermentation is the use of pure culture starters under sterile process conditions:

Table 2. Effect of lactic fermentation on pH and acidity of sorghum (40% flour, 30°C 24-h intervals, back-slopping 3%).

	pH	Acidity (% w/w) (expressed as lactic acid)
Fresh flour	6.52	0.17
Fermented once	4.15	0.60
Back-slopped 3 times	3.90	0.85

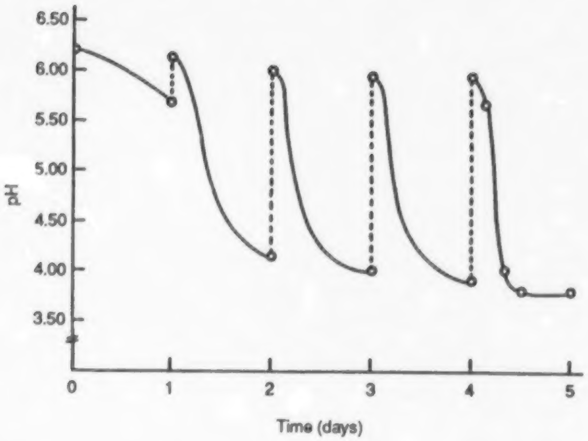

Fig. 2. Lactic fermentation of sorghum (back-slopping 3%; 30°C).

an example of this method is the lactic fermentation of maize "uji" with pure cultures of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, carried out successfully by Mbugua (1987); this technique would be suitable for the controlled conditions of large-scale industrial operations.

Table 3. Selection of microflora during back-slopping lactic fermentation of sorghum at 30°C (40% flour in mixture) (colony forming units; counts expressed as log N/g).

Microflora[a]	**Fresh sorghum flour**	**Number of fermentation cycles**			
		1	**2**	**3**	**4**
Total aerobic bacteria (PCA)	4.7	> 7.0	> 7.0	10.0	9.6
Enterobacteriaceae (VRBG)	3.0	6.5	< 1.7	< 1.7	< 1.7
Yeasts and fungi (OYEG)	2.7	6.5	7.5	7.7	7.7
Lactic acid bacteria (MRS)	4.2	> 8.0	9.1	9.7	9.7
Lactobacillus (Rogosa)	3.4	> 8.0	9.0	9.5	9.5

[a] PCA, Plate Count Agar; VRBG, Violet Red Bile Glucose agar; OYEG, Oxytetracyclin Yeast Extract Glucose agar; MRS, de Man, Rogosa, and Sharpe agar.

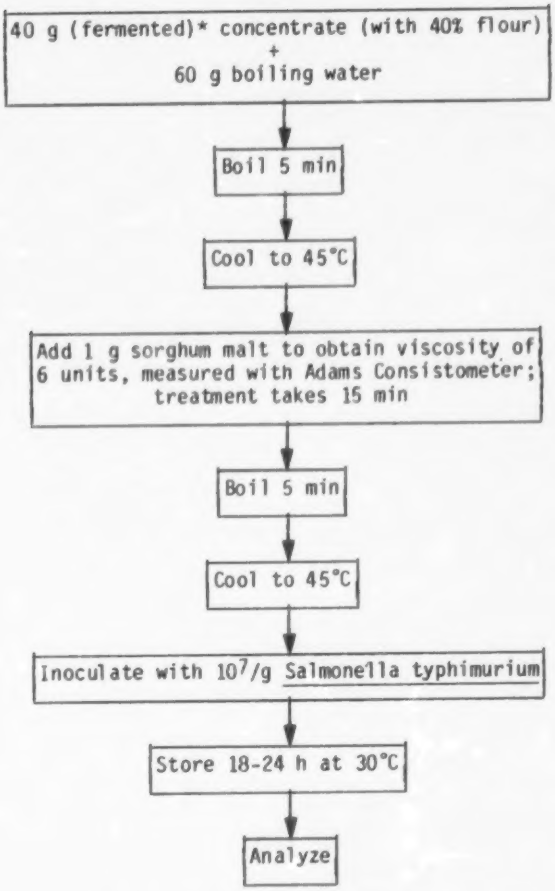
40 g (fermented)* concentrate (with 40% flour)
+
60 g boiling water
Boil 5 min
Cool to 45°C
Add 1 g sorghum malt to obtain viscosity of 6 units, measured with Adams Consistometer; treatment takes 15 min
Boil 5 min
Cool to 45°C
Inoculate with 10⁷/g Salmonella typhimurium
Store 18-24 h at 30°C
Analyze

Fig. 3. Experimental procedure for porridge-making and stability testing. *, optional treatment.

Microbiological Stability of Sorghum Porridge

To study the effect of lactic fermentation on microbiological shelf-life, sorghum porridge with about 15% dry matter was prepared according to the flow sheet given in Fig. 3. During this manufacturing process, sorghum malt was added to liquefy the thick gelatinized paste; this resulted in the desired consistency of 6 units, measured with an Adams consistometer. The thinned porridge was then boiled again to stop the enzymatic liquefaction and to cook the malt.

Relevant microbiological counts from the freshly prepared porridge are presented in Table 4; these show very low levels of live microorganisms, representing only some surviving heat-resistant bacterial spores. In terms of safety, therefore, the feeding of

Table 4. **Microbiological composition of freshly cooked and cooled sorghum porridge (counts expressed as log N/g).**

Microflora[a]	**Using fresh sorghum flour**	**Using lactic fermented sorghum concentrate**
Total aerobic bacteria (PCA)	1.8	less than 1.7
Enterobacteriaceae (VRBG)	less than 1.7	less than 1.7
Yeasts and moulds (OYEG)	less than 1.7	less than 1.7
Lactic acid bacteria (MRS)	less than 1.7	less than 1.7

[a] PCA, Plate Count Agar; VRBG, Violet Red Bile Glucose agar; OYEG, Oxytetracyclin Yeast Extract Glucose agar; MRS, de Man, Rogosa, and Sharpe agar.

freshly cooked porridge is recommended. Because of the potential for rapid spoilage, the keeping of leftovers is not recommended. We must, however, respect those situations in which food is precious and therefore difficult to discard.

It becomes important, therefore, to know more about the behaviour of microorganisms in stored porridge. To test the microbiological stability of porridges, we placed them under the worst possible conditions - 30°C for 24 h. However exaggerated these conditions may appear, they provide a certain factor of security and are valid for use in tropical climates.

Under domestic conditions, it will be difficult to avoid microbial contamination of the porridge during feeding. Fortunately, the presence of one or two live microorganisms in the porridge at the time of feeding is usually not a matter of concern. On the other hand, if storage facilities are inadequate and the porridge is kept at ambient temperature for some time, those few microorganisms will multiply rapidly, causing spoilage, public health hazards, or both. To test the products under adverse storage conditions, we simulated unhygienic handling by introducing *Salmonella typhimurium* (phage type II 505 ex RIVM (*National Institute of Public Health, The* Netherlands) isolated from patients' stools and rendered resistant to 200 ppm nalidixic acid) into the porridge at the beginning of the storage period.

Table 5 shows that in sorghum porridge made with fresh sorghum flour, the high pH (6.35 after preparation) permitted the germination and growth of heat-resistant spores of spoilage-causing bacteria (see PCA), even when the porridge had not been inoculated, and even when it was maintained under sterile conditions. When *S. typhimurium* was added after preparation, these multiplied quick*ly during stor*age (see PCA + NA, VRBG + NA).

High counts of bacteria such as *Escherichia coli* and *Bacillus cereus* were found in stored, nonfer*mented traditional* Gamb*ian weaning foods* (Rowland et al. 1978). Also reported was the severe contamination of Kenyan children's food with *Enterobactericeae* and *Staphylococcus aureus* (van Steenbergen et a*l. 1983). Un*fortunately, neither *of these report*s gives pH data of the tested samples; further analysis of the pH effect is, therefore, impossible.

Table 5. Microbiological stability of sorghum porridges (counts after 24-h storage at 30°C, expressed as log N/g).

	Using fresh sorghum flour		Using lactic-fermented sorghum concentrate	
	Not inoculated	10^7/mL *S. typhimurium* added	Not inoculated	10^7/mL *S. typhimurium* added
Total aerobic bacteria				
PCA	6.7		< 1.7	
PCA+NA		8.8		< 1.7
Enterobacteriaceae				
VRBG	< 1.7		< 1.7	
VRBG+NA		8.8		< 1.7
Lactic acid bacteria				
Rogosa	< 1.7	< 1.7	< 1.7	< 1.7
pH after boiling	6.35	6.35	4.25	4.29

Note: NA, 100 ppm nalidixic acid; PCA, Plate Count Agar; VRBG, Violet Red Bile Glucose agar.

In contrast, the pH of the porridge made from lactic-fermented sorghum was 4.25 after preparation. Under these circumstances, heat-resistant spores would not germinate. (Enough of the added *S. typhimurium* (10^7/g) were destroyed that it was below the detection level during storage (see VRBG+NA).

Stability After Addition of Supplementary Ingredients

Sorghum-composite mixes differ from sorghum with respect to their chemical composition and physical properties. In this study, only the following composite foods (presented in Table 1) will be considered:

- S-PP-O-M: sorghum-base, supplemented with pigeon pea and groundnut oil, and liquefied with sorghum malt;
- S-PP-M: sorghum-base, supplemented with pigeon pea, and liquefied with sorghum malt;
- S-GN-O: sorghum-base, supplemented with groundnut and groundnut oil (no further liquefaction required); and
- S-GN-M: sorghum-base, supplemented with groundnut, and liquefied with sorghum malt.

To investigate the effects of pigeon pea and groundnut, we used mixtures based on fermented sorghum concentrate and corresponding mixtures based on fresh sorghum flour. Pigeon pea meal, groundnut meal, or groundnut oil was added to the sorghum base just before the porridge was to be cooked. If required, the product was liquefied with the predetermined quantity of sorghum malt. Finally, the product was heated again to obtain a well-done porridge, as outlined in Fig. 3.

It is to be expected that the introduction of nonfermented ingredients will increase the pH of the resulting porridge, particularly if fermented sorghum concentrate is used as a basis. The extent of this pH increase depends on the quantity of ingredients added and on their buffering capacity. In our mixes containing groundnut, the final pH was higher than in the mixes with pigeon pea, due to the fact that greater amounts of groundnut than of pigeon pea were used in the recipes.

Microbiological data (Table 6) show that all products made with fresh sorghum flour permitted a rapid growth of heat-resistant bacterial spores and of added *S. typhimurium*. When lactic-fermented sorghum was used as a basic ingredient, however, the bacterial spores could not grow during storage, and the added *S. typhimurium* were to some extent destroyed. In this respect, mixture 2 was more effective against added *S. typhimurium*. Because of their relatively high initial pH values, mixes 3 and 4, with lactic-fermented sorghum, were not effective against *S. typhimurium*.

These experimental findings lead to an important conclusion. We see that it is possible to maintain the microbiological stability of lactic-fermented sorghum porridge, even if this porridge has been supplemented with certain fresh, high-protein ingredients. The choice of supplementary ingredients is important: their addition must not lead to final pH values (≥ 4.5) that permit the germination or growth of undesirable microorganisms.

Table 6. Microbiological stability of sorghum-based composite mixes, with supplementary ingredients added during porridge preparation (counts after 24-h storage at 30°C, expressed as log N/g).

		Not inoculated		*S. typhimurium* inoc.	
	pH after boiling	Total bacteria	*Enterobacteriaceae*	10^7/g after 24 h	10^3/g after 72 h
Using fresh sorghum flour[a]					
S-PP-O-M	6.50	8.0	<1.7	9.2	9.4
S-PP-M	6.35	8.3	<1.7	8.9	8.9
S-GN-O	6.65	8.4	<1.7	9.2	8.9
S-GN-M	6.52	8.9	<1.7	9.0	8.8
Lactic-fermented sorghum concentrate[a]					
S-PP-O-M	4.70	<1.7	<1.7	6.0	<1.7
S-PP-M	4.45	1.9	<1.7	3.2	<1.7
S-GN-O	5.45	7.5	<1.7	8.9	6.9
S-GN-M	5.12	1.8	<1.7	7.6	9.0

[a] S, sorghum; PP, pigeon pea; GN, groundnut; O, groundnut oil; M, sorghum malt.

Fermentation of Sorghum-Based Composite Mixes

A factor of significance in the promotion of improved weaning foods is the packaging and distribution of ready-made mixtures such as that of sorghum flour and pigeon pea meal or sorghum and groundnut. Such composite mixes could then be fermented at the household level. As was demonstrated, it is fairly easy to obtain a stable lactic fermentation of sorghum flour under simple household conditions.

We investigated the use of such ready-made weaning mixtures. Using the simple procedure outlined earlier (Fig. 1), we obtained the results presented in Table 7; these results indicate that a strong lactic fermentation can be readily obtained in composite mixes. At 30°C, pH values of 3.65 (S-PP) and 3.75 (S-GN) were reached after 12 h, with the stabilized system in which a portion of 10% was used every day for back-slopping. The development of the microflora in the fermenting composite flours followed the same trend as shown earlier in Table 3 for fermenting sorghum flour. The fermented composite flours were also processed into porridges. The required viscosity of the porridges was obtained using predetermined quantities of sorghum malt.

Table 8 shows that with both composite flours (S-PP and S-GN), lactic fermentation resulted in porridges (S-PP-M and S-GN-M, respectively) that caused the rapid destruction of added *Salmonella*. We have, therefore, results from two processes: in one of these

Table 7. Lactic fermentation of sorghum-based composite flours by back-slopping method at 30°C; 10% inoculum; 24-h intervals (counts expressed as log N/g).

Days back-slopped	Final pH	Total bacteria (PCA)	*Entero-bacteriaceae* (VRBG)	Yeasts (OYEG)	*Lactobacillus* (Rogosa)
		S(85.8%)-PP(14.2%)			
0 (fresh)	6.20	4.5	3.6	2.7	3.7
1	4.25	9.6	4.1	5.8	9.4
2	3.70	9.6	<1.7	7.1	9.5
3	3.70	9.8	<1.7	7.7	9.8
4	3.65	9.8	<1.7	7.2	9.7
5	3.65	10.0	<1.7	7.3	9.7
		S(56.5%)-GN(43.5%)			
0 (fresh)	6.40	4.5	3.8	2.3	4.3
1	4.29	9.6	3.9	5.4	9.1
2	3.81	9.6	<1.7	7.3	9.3
3	3.75	10.0	<1.7	8.2	9.9
4	3.75	9.7	<1.7	7.9	9.8
5	3.75	10.0	<1.7	8.0	9.9

Note: PCA, Plate Count Agar; VRBG, Violet Red Bile Glucose agar; OYEG, Oxytetracyclin Yeast Extract Glucose agar; S, sorghum; PP, pigeon pea; GN, groundnut.

Table 8. Microbiological stability of sorghum-based composite mixes from ready-made composite flours (counts after 24-h storage at 30°C, expressed as log N/g).

	pH after boiling	Not inoculated: Total bacteria	Not inoculated: Enterobacteriaceae	Inoculated: 10^3/g S. typhimurium
Using fresh composite flour[a]				
S-PP-M	6.32	8.4	< 1.7	9.3
S-GN-M	6.50	8.7	< 1.7	9.5
Using lactic-fermented composite flour[a]				
S-PP-M	3.75	3.6	< 1.7	< 1.7
S-GN-M	3.85	3.8	< 1.7	< 1.7

[a] S, sorghum; PP, pigeon pea; M, sorghum malt; GN, groundnut.

processes, ready-made composite flours undergo lactic fermentation before porridge-making; in the other, the lactic-fermented sorghum base is supplemented with fresh ingredients during porridge-making. The data indicate that from a microbiological point of view, better results (much safer products) are obtained from the first of these processes.

Discussion

Our experiments were carried out with white sorghum, pigeon pea, and groundnut. These are dietary ingredients that are appropriate to many African communities; we feel, nevertheless, that we must broaden our data by studies of other staples and potential supplements. Although the scope of the present data may be limited, in our opinion these data indicate interesting prospects for the production, both at the household and at the large-scale level, of porridges of high nutritional quality and inherent microbiological safety.

Mention has been made elsewhere of the positive effect of lactic fermentation on the nutritional value of cereal products. Unfortunately, these data relate to products other than weaning foods. There is, therefore, a need for a more integrated research approach.

- Comprehensive chemical analyses are needed, covering macro- and micro-nutrients, as well as possible enzymatic conversions of antinutritional components such as phytic acid or tannins, and removal of contamination with, for example, aflatoxins.

- Tests for acceptability should be conducted, and efforts made at product development. Priority should be given to operational aspects at the household level. Such products could, however, be subjected to large-scale market trials as well, with control groups receiving nonfermented products of the same composition.

The monitoring of intake, weight gain, and nutritional status during some months of consumption by experimental and control groups could make a scientific contribution to the improvement of child nutrition.

- Investigations should be made into the therapeutic or prophylactic effects of regular consumption of lactic-fermented porridges.

It has been reported that in pigs and ducks, the colonization of the gut by pathogenic Salmonella sp. can be reduced using lactic-fermented feed ingredients (Fuller 1986). Little is known, however, about the bacteriological basis of these effects. Similarly, lactic-fermented foods have been associated with such beneficial effects in humans as curing of diarrhea, improvement of lactose metabolism, and activities that are anticholesteremic and even anticarcinogenic (Fernandes 1987). Lack of solid experimental data makes it impossible, however, to predict whether such benefits could be expected from the regular consumption of lactic-fermented cereal porridges. In our view, one research priority should be to study the effect of lactic-fermented porridges on the essential as well as on the undesirable components of the human gut microflora, on gain in bodyweight, and on the activity of selected enzymes of metabolic significance.

Conclusions and Recommendations

- The controlled lactic fermentation of porridge ingredients resulted in highly effective protection against the growth of S. typhimurium contamination and against the germination and growth of heat-resistant bacterial spores.
- There should be an investigation into the effect of this fermentation on other genera of the Enterobacteriaceae, as well as on certain of the more acid-tolerant toxigenic bacteria such as Staphylococcus aureus.
- Research should also be undertaken into the influence of lactic fermentation on the nutritive value of the porridges and the effect of these porridges on the composition of the gut microflora.
- Appeals should be made to potential sponsoring agencies to enable pragmatic, fundamental research programs to be carried out. In this respect, the scientific networks can be a valuable tool: they can help to promote the exchange of new findings, to establish cooperation projects, to facilitate staff exchange, and to coordinate field trials.

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BACTERIOLOGICAL PROPERTIES OF TRADITIONAL SOUR PORRIDGES IN LESOTHO

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Abstract *The bacteriological properties of fermented sorghum porridge, or "motoho," were investigated at the Microbiology Department, Queen Elizabeth II Hospital, Maseru, Lesotho. The "motoho" was prepared from a starter obtained in Maseru. The porridge was inoculated with the pathogens (Shigella boydii, S. typhi, enteropathogenic Escherichia coli 0126 and Salmonella sp. nonenteric) before, during, and after fermentation. Unfermented sorghum porridge ("leshele-shele") was treated identically, as a control. The results showed the "motoho" to have an acidic property, produced during fermentation, that eliminated the pathogens within 3 h. Starters were also taken from four areas around Lesotho, and the batches of "motoho" inoculated with the pathogens. These pathogens were again eliminated within 3 h. Not only does "motoho" not support the growth of pathogens, but it is available locally and is inexpensive.*

Sorghum is a staple crop in many African countries, including Lesotho. Traditionally, it is used to prepare stiff porridge, thin porridge, and a wide range of fermented beverages, including local beer. In this study, emphasis is placed on the fermented, thin porridge known in Lesotho as "motoho," and on the unfermented porridge known as "leshele-shele." Both are popular as weaning porridges and as foods for young children.

"Motoho" can be consumed at any time of the day, both by children and by adults, and is prepared at the household level. On arrival at a home, one is offered "motoho" as a beverage; it serves as an alternative for the tea or coffee of European families. Because it keeps longer and can be prepared in large amounts for future use, it is preferred over "leshele-shele." "Motoho" can be taken to the fields without losing its texture or taste, and is therefore popular among agricultural workers. "Leshele-shele," on the other hand, soon becomes tasteless and loses its consistency.

"Leshele-shele" is eaten mainly by the urban population of Lesotho. It is served for breakfast and sometimes throughout the day. It is quick and easy to prepare. "Motoho" is seldom prepared in the urban areas: it is considered old-fashioned by this sector of the population. "Leshele-shele" is also popular in the rural areas, however, especially with mothers who have just given birth: this unfermented porridge is believed to be extremely nutritious - an important factor for a lactating mother.

Preparation

"Motoho" is prepared by mixing fine-ground mealie (sorghum or maize flour) with lukewarm water. A bacterial culture, or "starter," is added to the preparation. This starter is usually obtained from a previous preparation. The mixture is wrapped in a blanket and left 11-13 h (usually overnight) to ferment. The following morning, a sieved mixture of the porridge is cooked in boiling water for about 20-30 min. Alternatively, in the villages, where grinding stones are still used, the mealie is ground very roughly, and after overnight incubation with the starter, is reground very finely and cooked as described. "Leshele-shele" is prepared by mixing a portion of fine-ground sorghum or maize flour mealie (either commercially prepared or locally ground) with water and boiling for 15 min to make a thin porridge.

Objectives

The objective of this project was to assess the ability of sour porridges to stop or retard the growth of pathogenic microorganisms that are responsible for causing diarrhea. The organisms investigated were Salmonella typhi, Salmonella sp. (nonenteric), enteropathogenic Escherichia coli 0126, and Shigella boydii. The unfermented porridge ("leshele-shele") was included for purposes of comparison, and nutrient broth was used as a control. The study also investigated the stage in the fermentation process at which the actual destruction of the pathogens occurs. Starters from different areas of Lesotho were tested for their ability to inhibit the growth of the bacteria.

Methodology

The following investigations were carried out:

- The cooked "motoho" and cooked "leshele-shele" were inoculated with similar dilutions of the above-mentioned microorganisms in ringers solution. They were incubated overnight at 37°C, then subcultured on MacConkey plates and, after 24 h, examined for growth.

- The uncooked "motoho" and uncooked "leshele-shele" were inoculated with dilutions of the microorganisms and incubated at 37°C. Subcultures on MacConkey plates were made after 1, 3, 6, and 9 h. These plates were incubated overnight and examined for growth.

- The uncooked "motoho" and uncooked "leshele-shele" were prepared and incubated at 37°C. After fermenting for 1, 3, and 6 h, the porridges were inoculated with dilutions of microorganisms.

They were subcultured after 1 h and after 3 h, and incubated at 37°C overnight to be examined for growth the following morning.

- "Motoho" was prepared in the laboratory using four different starters from various areas of Lesotho. These were cooked and inoculated with dilutions of microorganisms and incubated at 37°C. "Motoho" was subcultured after 3 and after 24 h on MacConkey plates. The plates were incubated overnight and examined for growth. "Leshele-shele" was similarly prepared and inoculated; the growth from "leshele-shele" was used as a control. Results are reported in colony counts, which were obtained by performing dilutions of 10^{-1} to 10^{-4}.

Discussion

Preparation and consumption of fermented sorghum porridge ("motoho") has been traditional in Lesotho. In this project, we have investigated the ability of "motoho" to inhibit the growth of certain diarrheal pathogens. There is no general agreement on methods for bacteriological examination of food; we have therefore chosen a general method for the estimation of the microbial content, i.e., "viable count."

We began our studies by inoculating "motoho" and "leshele-shele," as prepared in the home, with the pathogens. Both autoclaved and unautoclaved "motoho" effectively inhibited the growth of all the tested pathogenic bacteria. A few colonies of Salmonella at low dilution did, however, succeed in growing in the autoclaved "motoho." The "leshele-shele" had no inhibitory effect on the pathogens; in other words, it appears to have no antibacterial properties. The growth in all the dilutions was so confluent that it was impossible to count the colonies. Nutrient broth was used as a control, and it too yielded confluent growth. Autoclaving did not appear to influence results, either in "motoho" or in "leshele-shele." Thus we see that "motoho" has the ability to destroy those pathogens inoculated after fermentation has finished and the porridge cooked.

We then investigated at what stage of fermentation the inhibition of growth occurred. From Table 1, we see that the number of colonies in the "leshele-shele" was comparable to the number in "motoho" after a 1-h subculture. A comparison with the 3-h subculture shows that, whereas the pathogens in the "leshele-shele" continued to multiply, the pathogens in the "motoho" remained unchanged or decreased in number. In the 6-h and 9-h subcultures, the pathogens in the "leshele-shele" continued to multiply; those in the "motoho" were, however, completely eliminated, with the exception of a few colonies of enteropathogenic E. coli that grew on the 6-h subculture. The pH of the "leshele-shele" dropped from 7.1 to 7.0. The pH of the "motoho," however, decreased from 7.0 to 6.4; this suggests that an acid was being produced. The exposure time provided by 1 h of fermentation was not sufficient, however, to inhibit the growth of the pathogens.

The results seen in Table 2 were obtained when the pathogens were added to the "motoho" at intervals of 1, 3, and 6 h after fermentation had begun. It can be observed from the results that none of the pathogens was capable of surviving in the "motoho" 3 h after fermentation

Table 1. **Number of colonies counted when uncooked "motoho" and uncooked "leshele-shele" were inoculated with the organisms and subcultured after 1, 3, 6, and 9 h.**

	1 h	3 h	6 h	9 h
"Motoho"[a]				
Shigella boydii	24500	28000	0	0
Salmonella typhi	38000	40000	0	0
E. coli	2600	1800	40	0
Salmonella sp.	57000	850	0	0
"Leshele-shele"[b]				
Shigella boydii	26000	60000	200000	220000
Salmonella typhi	37000	110000	250000	300000
E. coli	2800	26000	600000	1000000
Salmonella sp.	59500	120000	2000000	3000000

[a] pH measured during fermentation was: 6.6, 6.5, 6.4, and 6.4 at 1, 3, 6, and 9 h, respectively.

[b] pH measured during fermentation was: 7.1, 7.0, 7.0, and 7.0 at 1, 3, 6, and 9 h, respectively.

Table 2. **Number of colonies counted when uncooked "motoho" and "leshele-shele" were inoculated with similar dilutions of organisms at intervals of 1, 3, and 6 h and subcultured after 1 and 3 h.**

	1-h inoculation		3-h inoculation		6-h inoculation	
	1-h SC[a]	3-h SC	1-h SC	3-h SC	1-h SC	3-h SC
"Motoho"						
Shigella	1500	0	0	0	0	0
Salmonella typhi	2500	0	7500	0	0	0
E. coli	30000	0	2000	0	0	0
Salmonella sp.	50000	0	0	0	0	0
"Leshele-shele"						
Shigella	1400	160000	3200	300000	3000	400000
Salmonella typhi	3300	30000	7000	200000	5000	200000
E. coli	140000		_[b]	_[b]	_[b]	_[b]
Salmonella sp.	200000	3×10^6	320000	8×10^6	340000	20×10^6

[a] SC = subculture.

[b] No figures available due to contamination.

had occurred. The pH tolerance of the microorganisms tested is 7.2 to 7.6; the pH levels of the "motoho" may therefore be responsible for the death of these pathogens.

Table 3 shows that the starters from different areas of Lesotho were equally effective in eliminating all the pathogens within 3 h. The pathogens in the "leshele-shele" showed a confluent growth after 24 h, whereas no pathogens survived in the "motoho."

Table 3. Number of colonies counted when "motoho" was prepared from four different starters, cooked, and inoculated with dilutions of microorganisms.

	"Motoho"				"Leshele shele"[b]
	S[a]	Q	M	C	
Subcultured after 3 h					
Shigella boydii	0	0	0	0	20000
Salmonella typhi	0	0	0	0	0
E. coli	$2x10^6$	25000	65000	26000	$3x10^6$
Salmonella sp.	0	0	0	0	0
Subcultured after 24 h					
Shigella boydii	0	0	0	0	Confluent
Salmonella typhi	0	0	0	0	"
E. coli	0	0	0	0	"
Salmonella sp.	0	0	0	0	"

[a] S, Semonkong; Q, Quthing; M, Maseru; C, Caledon.
[b] "Leshele-shele" was treated similarly and used as a control.

We had hoped that, given an inoculation of the appropriate dose of diarrheal pathogen, we would, after 3 h incubation, obtain 400 organisms of *Shigella boydii* and *S. typhi* and a million organisms of *Salmonella sp.* and *E. coli* 0126. *After trying various dilutions, we found that* it was *impossible* to achieve this. It would be interesting to know whether inoculation at the appropriate dose, as opposed to a higher dose (as in our context), would have changed the outcome.

Conclusion

Tables 1-3 show that fermented sorghum porridge ("motoho") becomes acidic, and that *Shigella boydii*, *S. typhi*, enteropathogenic *E. coli* 0126, and *Salmonella sp. (bacterial pathogens* likely to cause *diarrhea) are unable to survive* in such a medium.

Sorghum is locally available in Lesotho and grows on both highlands and lowlands. Because of the work involved in cultivating the crop, however, sorghum is not cultivated to the same extent today as it was 10 years ago. Ground sorghum may be purchased at local stores and is inexpensive. The method of fermenting the sorghum is uncomplicated and results in a more palatable porridge.

It is indicated by the tests conducted in this study that "motoho" is capable of inhibiting the growth of certain microorganisms, and that this capability arises from the creation, during fermentation, of a low pH. Porridges become contaminated at the initial stages of preparation by impure water or when microbes are transferred from the hands of food handlers (Tompkins et al., this volume). Hot weather could also contribute to a high level of contamination occurring between preparation and consumption. Because "motoho" is capable of destroying certain diarrhea-causing microorganisms, it appears safer to recommend this porridge, rather than unfermented porridge, as a weaning food for young children.

DISCUSSION SUMMARY

General Discussion

It was emphasized that the porridge under discussion in Dr Simango's paper was "fresh" and not soured in any way. In such studies, the presence of E. coli is used as an indicator for fecal contamination; it was suggested that other organisms, such as Streptococcus faecalis, be studied. Dr Brown stated that although it would be desirable to examine the growth of specific organisms known to cause diarrhea, this was, in practice, extremely difficult. The levels of certain of these pathogens are very low and it is difficult, therefore, to obtain samples of food large enough to show the presence or concentration of such pathogens. The presence of E. coli remains, therefore, a useful indicator. It was stated that the microbiological properties of the porridge might be modified by cooking; as described in the paper, however, the "mahewu" was not heated before consumption. A point of clarification was offered regarding the detection of E. coli: there are some types of E. coli that occur in plants and are not harmful; the presence of E. coli of fecal origin is, however, important, and calls for special culture techniques to detect the organism.

With regard to the paper by A. Pertet, Dr Nout said that he was not surprised at the high level of bacterial contamination found in the porridges: many of these porridges were cooked at very low temperatures - temperatures that suggested incubation, rather than cooking. Effective cooking means heating to at least 80°C.

Questions were raised concerning the unexpectedly high pH levels reported by Dr Sakoane for "motoho." Dr Sakoane accepted that these were unusual, and suggested that the problem may have been one of measurement. The porridges did taste sour, and probably had lower pH levels than those reported in the paper. She said that the pH levels would be checked again using different equipment. Also questioned was the origin of the strains of pathogenic bacteria used in the study. The importance of this point lies in the postulation that some pathogens may have developed resistance to local antibacterial products present in the fermentation. Dr Sakoane replied that the pathogens used in her experiments were ones of local importance.

The question was raised as to whether the same antibacterial effect would be found were the pH of the porridge to be reduced through the addition of lime or tamarind juice. Dr Sakoane replied that this had not been investigated. Although the practice is not common in Lesotho, some mothers add powdered tartaric acid to porridge. "Motoho" is often served with a little sugar; salt is not added.

Dr M.N. Nyathi brought to the attention of the conference the possibility of food poisoning from "mahewu." It is generally thought that fermented cereals contain fewer microbial contaminants than do cereals that are unfermented. At Mpilo Central Hospital in Bulawayo, Zimbabwe, however, cases have been reported of whole families suffering from food poisoning that may have been caused by fermented maize meal or "mahewu." "Mahewu" is traditionally prepared with leftover cooked maize meal, into which water and a fermenting substance are introduced; this mixture is left overnight and then served as a beverage. A survey was conducted at Mpilo Hospital's antenatal clinic with 25 mothers, each having at least four children. This survey showed that the earliest age at which children are given "mahewu" is about 2 years.

Dr Nyathi provided the following brief case report of possible "mahewu"-induced food poisoning. Eight children, all of one family, were admitted to hospital. Five of these children were diagnosed as having food poisoning; these five children had drunk "mahewu." The other three children had no symptoms; the only food they had not shared with the family that day was the "mahewu." Because the symptoms had appeared so soon after ingestion of the "mahewu," parents and neighbours were convinced that this food was responsible for the illness. The worst affected were the two youngest, aged 3 and 4 years, who were mildly to moderately dehydrated after several bouts of diarrhea and vomiting. These children were treated with an oral rehydration solution and were ready for discharge the next day.

It was pointed out that there could be many causes for this food poisoning, including chemical contamination from pesticides or containers. Dr Nyathi replied that in her investigations, it had not been possible to ascertain definitively the cause of the poisoning.

The group suggested that the practice of preparing "mahewu" from leftover porridge may in itself be dangerous: in addition to possible contamination by hands, etc., the porridge would initially be neutral in pH, and pathogens would therefore be able to proliferate before acidity had had a chance to develop. It was recommended that the production of this type of porridge be discouraged.

At this point, two areas of future research were suggested:

- to determine if fermented food reduces the duration of diarrhea in children? (In many countries, diarrhea in children represents the loss of about 30% of ingested food.)
- Why, despite all the problems associated with weaning porridge, are many children (40%, according to Dr Brown's paper) able to maintain an adequate energy intake? Research could examine the possible relevance of breastfeeding and of feeding frequency.

A question was raised concerning the negative relationship between feeding frequency and energy density. In Dr Brown's study, because no germinated grain was used to modify the viscosity of the "ogi," increased energy density correlated with increased viscosity; this may partly explain the lower frequency with which thick porridges were given. Dr Brown agreed that this may be the case and stated that the method of feeding (whether by hand or from a cup) may also have influenced this relationship.

Role of Fermentation in Preventing and Managing Diarrhea

The chairperson posed three questions to be considered by the participants:

- What is known about the role of fermentation in preventing bacterial contamination of weaning food?
- What is known about the role of fermented foods in preventing diarrhea within the community?
- What is known about the role of fermented foods in the management of diarrhea?

Question 1

It was generally agreed that blanket approval could not be given to the use of fermented foods in general, and that it was important to define fairly precisely the conditions and ingredients to be used in the preparation of such foods. It was considered more useful to discuss products and processes than the potentially confusing names of foods.

The discussion returned to antimicrobial effects. Dr Nout stated that in his opinion, the pathogenic bateria were killed through a combination of low pH and the presence of lactic and acetic acids. Although some lactobaccili did produce antibiotic-like substances, these were relatively unimportant in most lactic fermentations. Experiments had been conducted using artificially acidified foods; effects were found similar to those reported in Dr Nout's paper.

It was agreed that substantial evidence had been produced in the papers by Dr Nout and Dr Sakoane to show that a range of pathogenic microorganisms important in causing human disease were eliminated or reduced during the lactic fermentation of cereal gruels made from maize or sorghum. Although it would be desirable to extend these experiments to cover other pathogens and other types of fermentation, the current need is to examine the relevance of this work to the treating of diarrhea in the community.

Question 2

It was agreed that there is, at present, insufficient knowledge to answer this question. For the purposes of an intervention trial, it may be difficult to persuade mothers to adopt the relatively complex methods of fermentation; a comment by Dr Nout, however, that the same effect could be gained by adding lactic or acetic acids to porridge, suggests a possible methodology for a randomized community trial.

It was agreed that diarrhea has multiple causes, and that single-sector interventions have largely failed. It was suggested that a package of interventions holds more promise.

In addition to the controlled trial methodology suggested by Dr Brown, it was pointed out that there are, within the region, opportunities for natural experiments. Communities that use sour porridges extensively for weaning could be compared with nearby communities that do not; such comparisons could form the basis of a study on diarrhea in young children. Dr Greiner pointed out that because only about 25% of diarrhea can be attributed to the consumption of contaminated food, such a study would have to be made in a community in which diarrhea prevalence is very high. It would also be necessary to look for a situation in which fermented foods are known and found acceptable, but are not widely used.

Question 3

Again, present data appear insufficient to allow an answer to this question. There was conflicting evidence about the use of "obusera" in the treatment of diarrhea in Uganda. It was pointed out that foods with too high a concentration of sugar are not effective rehydration agents, and can, in fact, cause osmotic diarrhea. There is much in the literature about the therapeutic properties of fermented milk products, and it was suggested that these findings be tested in experiments with fermented cereals.

Session V

Experiences in East Africa and Asia

DIETARY BULK IN WEANING FOODS AND ITS EFFECT ON FOOD AND ENERGY INTAKE[1]

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Abstract *The dietary bulk problem in weaning diets has recently attracted much attention, both because of its clear association with malnutrition in young children, and because of the practical solutions that have been proposed. The two characteristics that determine dietary bulk are volume (or energy density) and consistency. Dietary bulk properties appropriate to young children would be high energy density (low volume) and semiliquid consistency. "Ugali" has a high energy density but stiff consistency, whereas "uji" has a liquid consistency but low energy density; the ideal porridge would combine the positive aspects of each. The use of traditional household technologies offers a potential solution to this problem. Flour from germinated sorghum or millet is known as "kimea," or "power flour" (P.F.); when this P.F. is added during cooking, thick porridges with adequate energy density can be liquefied within a few minutes. Food intake studies at the village level in Tanzania investigated the extent to which the consistency and energy density of a diet would influence actual food intake in young children. In the age group 12-36 months, the children were able to consume about 35% more of the semiliquid diets ("uji" and P.F.-treated "ugali") than of the stiff "ugali" diet. The total food intake in kcal per meal was 2-4 times more of the P.F.-treated "ugali" than of the ordinary "uji," and about 30% more than of the stiff "ugali." Children over 3 years of age were able to consume equal amounts of the stiff "ugali" and of the P.F.-treated liquid porridge.*

Nutritionally, there are two biological revolutions in a human life. The first occurs at birth, with the change from intrauterine nutrition to breastfeeding. The second occurs with the initiation of weaning; the "weaning period" has come to mean that period during which an infant gradually becomes accustomed to foods supplementary to breast milk. The first of these transitional periods may involve some problems but no real risk, even under unhygienic and poor social conditions. Under such circumstances, however, the second phase becomes one of high risk: the dietary system of the infant is no longer under the biological control of the mother's body, but depends on the knowledge and resources of the family.

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[1] These studies have been carried out in collaboration with the Tanzania Food and Nutrition Centre and funded by the Swedish Agency for Research Cooperation with Development Countries.

We know that under good social and economic conditions, when milk-based weaning foods can be given under medical supervision, the risks can be diminished. Such conditions do not, however, exist in most parts of the world, and nutrition problems during the weaning period are, therefore, widespread. The child must become accustomed to consuming and digesting new foods of often inferior nutritional quality, while being highly susceptible to numerous infections of the intestinal canal that are likely to be introduced as a result of unclean hands and utensils. This situation constitutes the greatest emergency facing the world's children today.

According to UNICEF (1987), covering 64 developing countries representing a population of over 2 billion, more than 30% of children under 5 years of age are suffering from moderate malnutrition, and about 5% are severely malnourished. Malnutrition is at its height during the weaning period - in many developing countries, the time between 6 months and about 2.5 years of age (Gordon et al. 1967). Earlier generations recognized the risks, and breastfeeding and weaning practices are, therefore, usually regulated by cultural and religious tradition (Jelliffe 1955). The best-known and most important tradition is that of prolonged breastfeeding beyond 4-6 months, supplemented by softer portions of the family diet (Cameron and Hofvander 1982).

In most cultures, traditional weaning foods are nonmilk family foods, based on the local staple - usually a cereal, such as corn, sorghum, millet, or rice. Noncereal staples, such as potatoes, cassava, and plantains, are sometimes used. When a staple is prepared as a weaning food, it is usually made either into a thick porridge, or into a soft or liquid gruel. Prepared as a liquid, these staples will hold large amounts of water, and thus become voluminous with a low energy and nutrient density. (Energy density is defined as the amount of energy per gram of food; nutrient density is the amount of nutrients per gram of food.) The flour concentration can be as low as 5%; this would give only 0.2 kcal/g of prepared gruel. To be able to meet his or her daily energy requirements, a young child would have to consume between 3 and 5 L of such a thin gruel, and that is clearly impossible. The high energy requirements of young children, together with their limited stomach capacity, make it impossible for them to eat enough of the food, particularly if the number of meals per day is low.

The term "bulk" is derived from the old English word "bulke," meaning magnitude or volume, and also mass or aggregate, especially that which is large. "Dietary bulk" can be produced in either of two ways. In the first, the energy density of the thin gruel ("uji") is too low, and the required volume therefore too large. The second characteristic of dietary bulk manifests itself when food volume is diminished by a reduction in dilution; in this case, the result is a stiff porridge ("ugali"). The amount of flour in such a porridge is about 30%; this gives an energy density of 1.0 kcal/g. This is the type of food that is preferred by adults; children from about 2 years of age are introduced to it. The stiff and sticky consistency of the "ugali" makes it more difficult to consume, especially for young children who may not have developed their full capacity to masticate and to swallow stiff and solid foods. Although the energy density is acceptable, the consistency may therefore be a major constraint in providing young children with enough food. It would obviously be desirable to be able to combine the good properties of each (the high energy density of the "ugali" and the semiliquid consistency of the "uji") into one food item.

To evaluate the influence of dietary bulk properties on the nutrition of young children, one must first consider those factors that determine daily energy and nutrient intake (Ljungqvist et al. 1981): number of meals per day, amount of food consumed at each meal, energy and nutrient density of the food consumed, and bioavailability of energy and nutrients in the food. Of these factors, the 2nd and 3rd are the ones most closely related to the dietary bulk properties of the food.

Dietary Bulk and Protein Energy Malnutrition (PEM)

Dietary bulk is often mentioned as a possible or even probable factor in the etiology of malnutrition (PAG 1973; Waterlow and Payne 1975; Payne 1976). Two original descriptions of infant feeding in West Africa were given by Cicely Williams, first in 1933, in her classical account of kwashiorkor, and later in her 1938 survey of the general child-health situation in the Gold Coast. She vividly describes the ill effects of the bulky, spiced carbohydrate foods given to older infants. In East Africa, Trowell and Muwazi emphasized as early as 1945 the bulky, indigestible nature of the food on which infants are weaned. These researchers state that the 1200 calories required daily by a child 2 years of age must be obtained from the consumption of bulky vegetable foods.

Very few attempts have been made, however, to study systematically the importance of the problem of dietary bulk in child feeding. Some authors have observed that starch-based diets have a very "bulky appearance" (Jones and Pereira 1972; Chamberlin and Stickney 1973; Binns 1975); it is not clear, however, whether they refer to the volume or to the consistency of the diet.

Nicol (1971) was one of the first to make quantitative estimates of the dietary bulk factor, based on studies of food intake in children. He concluded that the volume of starch-based foods required to cover the energy needs of preschool children is between 900 and 1650 mL. The amount of food eaten ranged from 660 to 1250 mL, divided into two meals per day; this was not enough to meet the energy requirements stipulated by FAO/WHO (1973). Even if the food were to be divided into many meals per day, Nicol concluded, it would be impossible to expect a child 1-3 years of age to enjoy 1450 mL of thick, sticky yam porridge. For cereal-based diets, however, it was considered possible for a child to consume a sufficient volume of porridge (900-980 mL) to meet his energy requirements if the food were divided into four servings per day. The consistency of this diet was not measured, but can be assumed to have been similar to that of a thick porridge.

Rutishauser (1975) compared energy density, feeding frequency, and "appetite" (depending on the presence of illness), with regard to the energy needs of preschool children; she concluded that energy density is the most decisive factor. Another interesting point arises from her data: in cases of discontinued breastfeeding, milk was the only food to provide full compensation; it would appear that milk has desirable dietary bulk properties that distinguish it from other starch-based foods.

Studies have been conducted on the feeding of preschool children in areas where starchy staples are the main foods and where PEM is prevalent. Researchers seem to agree that the "bulkiness" of the diet is a major constraint in providing children with enough food. This experience has, however, resulted in little investigation of means to alleviate the problem. More quantitative data are needed to show the importance of the dietary bulk factor.

Eating Capacity Related to Dietary Bulk

The food intake required to cover the energy needs of children of various ages with diets of different energy densities can be calculated from energy requirement data (FAO/WHO 1973). If the maximum intake level for a particular food is known, then we can determine the energy density needed to meet a child's energy requirement. From quantitative estimates on daily food intake, reported above, it can be assumed that young children would be able to satisfy their energy needs on a diet with an energy density of about 1 kcal/g.

Few studies have been devoted to measuring children's actual quantitative intake of different foods. Most studies relate to infants, either breastfed or bottle-fed with varieties of milk formulas. In studies of voluntary intake in preschool children, it is also difficult to avoid the influence of external factors, such as supervising personnel and altered meal patterns.

Studies of Food Intake in Infants

Fomon et al. (1969, 1971, 1975) carried out a series of studies on food intake in infants given, ad libitum, milk formulas with different energy concentrations. In spite of the greater quantity of food consumed by infants fed the low-calorie formula, their mean calorie intake (107 kcal/kg per day) was considerably less than that of infants fed the high-calorie formula (126 kcal/kg per day).

After the age of 4 months, the mean quantity of food consumed was 939 mL/day for the low-calorie group, and 582 mL/day for the high-calorie group; this resulted in an equal intake of calories/kg per day and in weight gain for all infants. All these studies, however, refer to milk-based formulas; the relevance for starch-rich weaning foods is not clear.

Studies of Food Intake in Preschool Children

Rutishauser and Frood (1973) studied the food intake in 19 Ugandan children aged between 1 and 3 years attending a rural child welfare clinic. All the children had early clinical signs of malnutrition. Ten of the children were fed a traditional family diet (a mixture of plantain and sweet potato, combined with either beans, groundnuts, or meat) five times daily, along with 500 mL of tea with 25 g sucrose. Nine children were given a milk-based diet (full-cream milk powder, sucrose, and cotton seed oil) at a rate of 100 mL/kg body weight per day. These children were allowed to supplement this diet with as much plantain or sweet potato as they wished. The experimental diets were offered for periods of 7-22 days. The mean total daily intakes were essentially the same for both diets - about 1200 g. The amount of solid foods in the family diet was slightly over 700 g/day; the authors concluded that this was near the maximum capacity of children aged 1-3 years.

Svanberg et al. (1987) report similar intake figures in a food intake study from an orphanage in Ethiopia. Twenty children aged 2-5 years were served a traditional Ethiopian diet, divided into 3 meals per day, and 1 meal consisting of a porridge. The range of daily food intake, liquid, and solid foods, over a period of 25 days, was 912-1367 g for the whole group of children. In a large study of English preschool children (Ministry of Health 1968), the average intake of foods, excluding milk, in children up to the age of 5 years, was 540 g/day, and with milk 900 g/day.

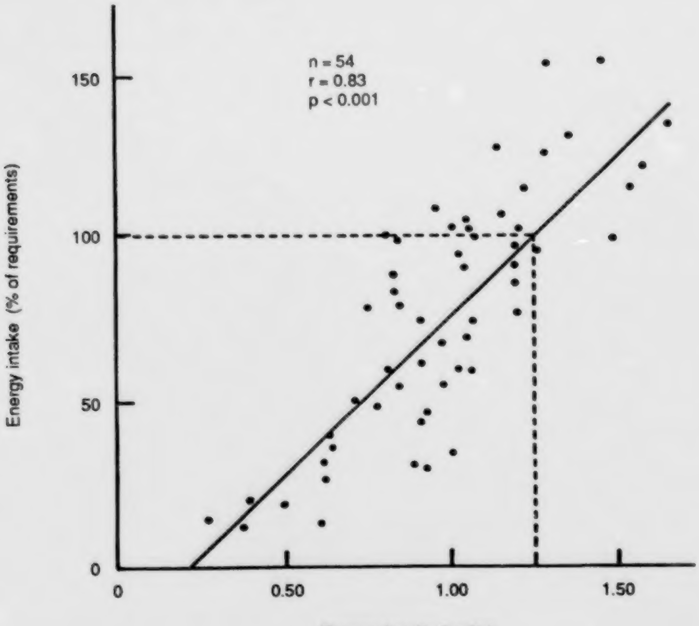

Fig. 1. Energy intake of young children as a percentage of requirements (FAO/WHO 1973) in relation to the energy density of the diet.

In conclusion, the data on food intake in preschool children (1-5 years) indicate a maximum capacity of about 900-1400 mL/day. If energy requirements are to be satisfied, these intake figures must be met by an energy density of about 1.2 kcal/g (FAO/WHO 1973). This estimation accords with data obtained from surveillance in villages and in nutrition rehabilitation centres in Tanzania (TFNC 1978; Mellander and Svanberg 1984). Figure 1 shows the actual intake, in percentage of requirements (FAO/WHO 1973), in relation to the energy density of the diet. A significant correlation was found between the daily energy intake and the energy density of the food. On average, an energy density of about 1.25 kcal/g of prepared food was needed to provide the estimated daily requirements; more than 70% of the children were eating meals with an energy density lower than this figure.

Church (1979) has compiled the data from Rutishauser and Frood (1973) in Uganda, and Binns (1975) in Papua, New Guinea. Figure 2 shows the results of these two studies. Even with very good appetites, these children had difficulty eating enough food to cover their energy requirements (Waterlow and Rutishauser 1974). The

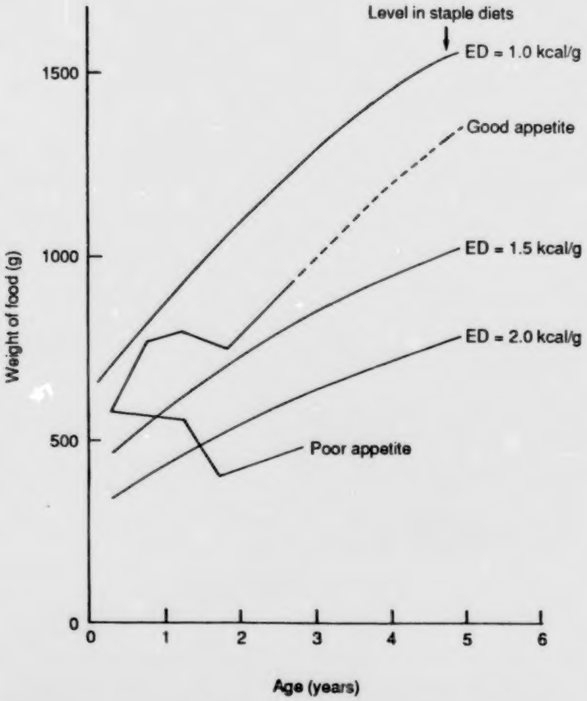

Fig. 2. Food intakes of children on a traditional, staple diet compared with the intake of foods with higher energy densities (ED) needed to meet the local standard for energy intake (see Rutishauser and Frood 1973; Waterlow and Rutishauser 1974; Binns 1975; Church 1979).

pattern of low food intake is characteristic and is strikingly exaggerated on days of poor appetite (in the Uganda study, on average, every 3rd day).

Using a 24-h oral recall method, Susheela and Narasinga Rao (1983) investigated the food intake of children in rural and urban areas of India. Children with heights and weights comparable to those of international standards consumed a diet with a mean energy density of 1.17 kcal/g; low-weight children, however, consumed a diet with the significantly lower energy density of 0.74 kcal/g. Svanberg et al. (1987) made sure of an energy density of 1.15 kcal/g in their study of experimental diets in Ethiopia; by Swedish standards, all the children were normal in weight-for-height.

With regard to satisfactory infant growth, the energy density of human milk should be considered optimal. Average values of 0.70 kcal/g have been reported for mature breast milk (Macy and Kelly 1961; Department of Health and Social Security 1977). We can conclude that in a mixed weaning diet in which liquids of lower energy density are consumed with solid food, the latter should have an energy density exceeding 0.7 kcal/g.

In conclusion, it is reasonable to assume that preschool children can satisfy their energy requirements on a diet with an average energy density of over 0.7 kcal/g; this holds true, however, only if the children are healthy and possess good appetites, and if their food is divided into more than three meals per day.

No data seem to be available on the influence of diet consistency on the eating capacity of children of various ages; the results mentioned above indicate no difference in the total daily intake between a more solid family diet and a liquid, milk-based diet (Rutishauser and Frood 1973). In a study at two orphanages in Ethiopia, however, it was observed (Svanberg, unpublished observation) that when a dry-blended weaning food (thick porridge) was used in the diet instead of an amylase-treated variety (liquid gruel), it was necessary to distribute the portions equally over the meals, otherwise the children would have had difficulty in eating their daily provisions.

An interesting contribution has been made by Church (1979), who discusses the consistency of weaning foods, particularly in relation to age and development as well as to diseases in children. The preference for more liquid foods is greater in younger children and increases with the increasing severity of an illness. When the diet is based on starchy staples, however, a higher liquidity in the weaning food means a decreased energy density.

Physiological Factors Related to Dietary Bulk

The factors regulating hunger and satiety in human beings are very complex and to a large extent have not yet been defined (Davidson and Passmore 1975). The present discussion is therefore limited to the probable effects of the energy density/volume and the consistency of a meal, in relation to the three basic phases of the digestive system: chewing and swallowing, gastric emptying, and intestinal digestion and absorption.

Chewing and Swallowing

Thicker foods necessitate more effort in chewing and in passing the chewed food on to the stomach. It is possible that this increased effort can limit food intake in young children who have not fully developed their abilities in these respects. Liquid foods, of course, require very little effort to be passed on to the stomach. At the same time, however, there will probably be less amylase (an enzyme needed to break down starch) from the saliva; this reduction in amylase may delay further digestion. None of these factors seem to have been studied adequately with different types of food.

Gastric Emptying

Hunt and Stubbs (1975) have carried out a large number of studies with regard to gastric emptying in adults; these studies cover a wide range of energy densities. The gastric emptying of a meal has been found to have an exponential shape (Hunt and Knox 1968): in other words, the total volume of the meal affects the rate of emptying. More important, however, is the fact that this rate is regulated by the energy density of the food: a meal of high energy density will be emptied more slowly than will one of low energy density. The regulation mechanisms seem, therefore, to be equally sensitive to all energy units, whether the origin of these units be fats or carbohydrates. These regulating mechanisms will not, however, fully equalize the differences between meals of different energy densities: a meal with a higher energy density will still release more energy into the intestines per unit of time than will a meal of lower energy density.

The viscosity of a meal also seems to exert a profound effect on gastric emptying. Gel fibres such as pectin and guar gum have been found to delay gastric emptying considerably in adults (Holt et al. 1979). It is not known whether this effect on gastric emptying can be achieved by the provision of highly viscous gruels of digestible carbohydrates, such as amylose or amylopectin, or both; these carbohydrates might be partly hydrolyzed by saliva amylases, resulting in a reduced viscosity.

Because of the ethical and practical problems involved in studying children, the information on gastric emptying rates in these age groups is scarce. There are, however, recent studies of small infants given adapted cow's milk (Singer and Fridrich 1975). These studies indicate that here also the emptying pattern is exponential. Gastric emptying time for half the given volume was found to be 87 + 29 min (mean + SD, n = 24) - a significantly longer time than that found in adults (Griffith et al. 1968).

Digestion and Absorption

The final digestion and absorption of the food components are usually concentrated to the proximal parts of the intestines (Johansson 1975). These processes may be extended to more distal parts of the intestines as a result of high rates of gastric emptying, or of a high content of unavailable carbohydrates (McCance et al. 1953). It is difficult to assess the possible influence of different rates of absorption with regard to dietary bulk as a limiting factor for nutrient intake.

Some further comments on the role of unavailable carbohydrates may, however, be pertinent. The important functions exercised by unavailable carbohydrates or "dietary fibre" are now being recognized. They constitute a source of unavailable energy, and they may also affect the availability of proteins and minerals (Southgate 1973). Furthermore, the undigestible carbohydrates bind large amounts of water and therefore contribute to dietary bulk: an example of this is pectin, carrying five times its own weight in water. Finally, emphasis must be laid on the profound effects of various diseases (in particular, those of the digestive tract), acute malnutrition, and various parasites, on appetite, digestion, and absorption (Latham 1975).

Reducing the Dietary Bulk

Traditional food-handling technologies have been shown to be able to reduce the water-holding capacity of cereals and legumes, and thus make it possible to prepare gruels with acceptable energy and nutrient densities but with semiliquid consistencies. We shall discuss two examples of such traditional, bulk-reducing methods: the first is sprouting (malting or germination) of cereals (Brandtzaeg et al. 1981; Mosha and Svanberg 1983) and of legumes in Asian and African countries; the second is fermentation, used especially in Africa to make edible the cassava and other starchy plants and roots.

The bulk-reducing effect of these processes depends on their formation of amylases. Enzymatic activity increases rapidly in germinating seeds; in some cereal varieties (barley, sorghum, and millets) the amylolytic activity is especially high. The alpha-amylases are synthesized in the cell within the aleurone layer; from here, they migrate into the starchy endosperm, where hydrolysis of the starch granules begins. These starch granules will therefore not swell to the same extent during cooking, and the amylose chains supposed to form the gel network will be broken down. The alpha-amylase activity developed during germination will thus reduce the water-holding capacity of gruels prepared from germinated flours. Sorghum (white varieties) and millets have been shown to develop significant amylolytic activity after 48 h of germination; other cereals and brown sorghum varieties may need more than 96 h of germination. (Figure 3 shows the dramatic effect on the bulk properties of a millet variety after germination.) At least three times as much germinated flour can be mixed into the same volume of water while maintaining the same consistency of gruel.

Furthermore, after germination, certain varieties contain amylolytic enzymes that are both soluble and so active that they can be used to degrade the starch gel network in gruels prepared from ungerminated flour. This means that, with the addition of a small amount of germinated flour, a sticky porridge of about 20% flour concentration will become a semiliquid gruel (Mosha and Svanberg 1983).

Many microorganisms participate in fermentation; some of these have been shown to produce amylases that could influence the bulk properties of, for example, cassava flour. Of particular importance are the acid-producing microorganisms. It is usually lactic acid that is produced; the pH of the product can be as low as 4.0 - a pH in which the starch component may lose its water-holding capacity.

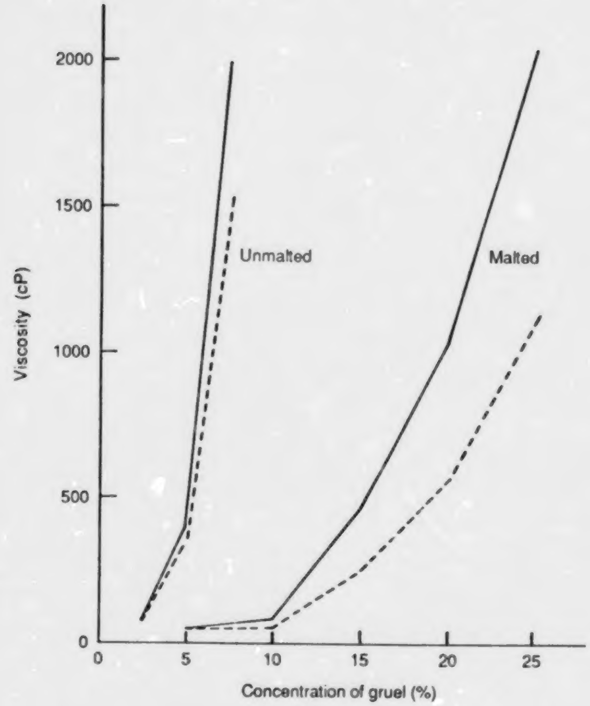

Fig. 3. Effect of cooking method on the viscosity of gruels prepared from unmalted and malted dehusked ragi flour. ——— , flour mixed directly with boiling water and cooked for 3 min; – – – , flour mixed with cold water and heated slowly. Viscosity was measured at 40°C in a Brookfield viscometer.

Table 1 summarizes in quantitative terms the effect of different bulk-reducing measures that can be carried out at the household level. It lists the energy densities of various weaning gruels that have been prepared with a semiliquid consistency. A proposed adequacy level (adequate for a 2-3 year old child) of 1.15 kcal/g is obtained from the average requirement for energy given by FAO/WHO (1973), and assumes a total daily food intake of about 1200 g for children in this age group.

When ungerminated cereals are used as a starch base in the gruel preparation, the energy density is around 0.30 kcal/g - as high as 0.50 kcal/g, if waxy varieties with favourable types of starch granules are used (Hellstrom et al. 1981). The addition to a nonwaxy cereal and cooking oil or a mixture of cowpeas and groundnuts (4:1) also results in energy densities of about 0.50 kcal/g. To reach the minimum desirable energy density of 0.70 kcal/g, it is necessary to mix cereal and groundnuts in a 3:1 ratio. When germinated sorghum (white) and millets are used to prepare a semiliquid gruel, it is possible to reach energy densities of 1.0 kcal/g or even higher (up to

Table 1. Energy densities of weaning gruels prepared to a semiliquid consistency measured against a proposed adequacy level of 1.15 kcal/g for a 2-3 year old child.

Weaning gruel	Energy density (kcal/g)[a]
Ungerminated cereals	
Nonwaxy	0.24 - 0.47 (0.37)
Waxy	0.28 - 0.58 (0.45)
Starch granule	0.41 - 0.54 (0.45)
With cooking oil	0.37 - 0.68 (0.51)
With cowpeas (4:1)	0.35 - 0.51 (0.43)
With groundnuts (4:1)	0.41 - 0.66 (0.52)
With groundnuts (2:1)	0.55 - 0.77 (0.65)
Germinated cereals	
White sorghum and millets	0.68 - 1.02 (0.81)
Brown sorghum	0.31 - 0.81 (0.46)
Maize	0.39 - 0.86 (0.56)
Sorghum/millet with groundnuts (4:1)	0.82 - 1.15 (0.98)
Sorghum/millet with cowpeas (4:1)	0.53 - 0.81 (0.64)
Any cereal/root with "power flour"	0.82 - 1.15 (0.97)
Fermentation	
Cereal/root	0.33 - 0.86 (0.45)

Note: Minimum acceptable energy density = 0.70 kcal/g.
[a] Mean values are shown in parentheses.

1.15 kcal/g, by mixing with groundnuts or by using the germinated flour as a "power flour," or P.F.).

Intake of Bulk-Reduced Weaning Foods

We have, in collaboration with the Tanzania Food and Nutrition Centre, conducted studies on dietary bulk in weaning foods; as part of these investigations, we have been able to carry out controlled food intake studies on young children at the village level with weaning foods of different dietary bulk properties.

In the Luganga village study, three different diets were prepared from the same double-mixture of maize flour and groundnuts (95/5). Diet 1 was a liquid "uji" with 5% flour concentration. Diet 2 was prepared as thick porridge with 20% flour concentration. Diet 3 was as diet 2, but liquefied by the addition of germinated sorghum flour (P.F.). The participating 32 children were served each diet on 3 consecutive days per month, over a period of 6 months. Table 2 shows a summary of the food intake data, with the children divided into four age groups. Eighteen children, 12-48 months old, consumed significantly more of the liquid gruels than of the thick porridge. Children over 48 months of age showed no significant difference in food intake with the three diets.

We can conclude, therefore, that for children between 12 and 48 months of age, it is the viscosity (consistency) and not the energy

Table 2. Average food intake (g) in young children of gruels of different dietary bulk properties.[a]

Children's age (months)	Flour concentration in gruel 5% (liquid)	 20% (without P.F. - thick)	 20% (with P.F. - liquefied)
5-12 (n=4)	154 ± 77a	153 ± 72a	163 ± 106a
12-24 (n=8)	330 ± 118a,b	277 ± 93a	346 ± 94b
24-48 (n=10)	491 ± 201a	405 ± 141b	445 ± 172a
48-65 (n=10)	544 ± 90a	517 ± 107a	565 ± 99a

[a]Mean values within the same group followed by a different letter are significantly different at P = 0.05 (the Wilcoxon signed rank test for paired samples).

density of the gruels that will affect food intake. This accords with the results of studies by Svanberg et al. (1987) on Ethiopian children fed the sorghum-based weaning food "faffa," bulk-reduced by the addition of 5% germinated sorghum flour. In that study, two weaning gruels of nearly the same viscosity but with different energy densities were consumed in equal amounts at single meals. Children between 1 and 2 years of age were the most sensitive to the consistency of the diet. This is the age group for which supplementary feeding is supposed to cover a large part of the energy and nutrient requirements, and the group in which the malnutrition problem reaches its peak.

The intake figures obtained in this study could be used to estimate the quantities of different weaning gruels needed per day to meet the energy requirements of preschool children. Table 3 compares gruels with different dietary bulk properties, showing the levels of

Table 3. Estimated consumed volume of gruels with different dietary bulk properties needed to supply 60% of daily energy needs for a child 1 year of age.[a]

	Flour concentration in gruel 5% (liquid)	 20% (without P.F. - thick)	 20-25% (with P.F. - liquefied)[b]
Volume to supply 60% of daily energy needs (mL)	3540	870	710-870
Actual intake per meal (mL)	330	277	347
Number of meals needed per day	10	3.1	2.0-2.5

[a]Energy requirements for children 1 year of age - 1180 kcal/day.
[b]Germinated sorghum flour added (5% of total amount).

gruels with different dietary bulk properties, showing the levels of food intake needed to cover 60% of the daily energy requirements for a child 1 year of age. It is assumed that breast milk will cover the rest of the requirements. Over 3500 mL/day of the 5% maize/groundnut gruel is needed; this is obviously impossible for a child of 1 year to ingest. Of the 20% thick gruel, about 870 mL/day will be needed. This could be divided into three meals, according to the observed average intake of 277 mL/meal. Using the P.F. technique, it is possible to have flour concentrations of up to 20-25%. The requisite amount of such gruels would be in the range of 710-870 mL/day; 60% energy coverage could therefore be reached with only 2 or 3 meals a day. The importance of a weaning food of such high energy density is further emphasized by the fact that in Tanzania, children under 5 years of age are usually fed only two or three times a day.

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HIGH-NUTRIENT DENSITY WEANING FOODS FROM GERMINATED CEREALS

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Abstract *Sorghum and maize were investigated for dietary bulk and food intake. Germinated and ungerminated flours were compared in the preparation of weaning gruels; using equal volumes of porridge, it was found that 3 times as much germinated flour (of the low-tannin sorghum varieties) could be used, while maintaining the same consistency of the gruel. Germinated flour of high-tannin sorghum varieties did not have this effect. The addition of 5% germinated low-tannin sorghum flour (enzyme rich) to thick ungerminated sorghum and maize gruels reduced the viscosity to acceptable weaning-food consistency. This method of reducing the dietary bulk of weaning food was accepted and used by mothers at the village level. Food intake by preschool children 12-48 months of age was significantly higher for bulk-reduced, low-viscosity gruel with 20% solids, than with untreated gruel. It was concluded that the use of bulk-reduced weaning foods of high nutrient density could eventually improve the nutritional status of young children and raise the nutrient intake of the infirm.*

Observations of traditional child feeding practices in many developing countries reveal that the weaning period, defined as the period during which breast milk is being replaced by other foods, usually begins when the infant is 4-6 months old, and is extended to the age of 2-3 years (UNICEF 1985). During this time, the children must eat from the family pot. In our countries, these foods are mainly starchy tubers, such as cassava and sweet potato, or cereals such as maize, rice, sorghum, and millet. Small children are usually given gruels made from these staples. When prepared in this way, the starch structures bind large amounts of water; this results in gruels of high viscosity (Tanzania Food and Nutrition Centre, internal report). Such gruels need to be further diluted with water to give a consistency that is appropriate for child feeding. This dilution, however, decreases the energy and nutrient density of the gruel, and children must then eat large amounts to satisfy their requirements; consumption of the amounts in question is physiologically impossible. This high volume/viscosity characteristic of a diet is usually referred to as "dietary bulk," and the importance of this factor in relation to child feeding has already been investigated and reported elsewhere (Mosha 1984, 1985; Svanberg 1985).

In Tanzania, the diet in most households, particularly those in rural areas, consists of one staple food, supplemented with green leafy vegetables, beans, or peas; a few well-off families occasionally have meat as a supplement (UNICEF 1985). In a few areas, such as the lake zones, fish is abundant, and in the savanna areas of the central and northeastern parts of the country, milk is in plentiful supply; both these foods contribute substantially to the energy and protein content of the diets.

Although not the preferred food, the most common diet in the country is maize, followed by rice, bananas (plantain), cassava, sorghum, millet, sweet potatoes, and round potatoes. Cereals are normally prepared as a stiff porridge ("ugali") for adults, and as a thin gruel ("uji") for small children. Bananas and potatoes are boiled.

When comparing both the energy and the protein requirements for adults and children, it has been found that requirements for the latter are relatively high in relation to body size (Cameron and Hofvander 1983). In most cases, the amount of food that a child can eat per meal is very much influenced by the ability to chew and by stomach capacity, both of which increase with age. On the other hand, the amount of food a child actually eats depends on the consistency and potability of the food, and on the time and patience of the mother when feeding.

The period of a human being's development from the fetal stage to the preschool stage is critical to growth; during this period, adequate food intake (including that of weaning foods) is vital to good nutritional status.

Industrial manufacture of cereal-based weaning foods often includes operations intended to reduce dietary bulk; examples of such operations include enzyme (amylase) treatment, precooking, and extrusion. Although these processes result in lower water binding in the gruels, as sophisticated technologies, they make for rather expensive products (Anon. 1970); in poor countries, these products are usually available only to the urban children of higher income families.

An alternative to these industrial processes could be an increased use of improved traditional food preparation procedures that will modify starch structures. One such procedure that is widely known and used is germination. Although germination of cereals is mainly associated with the preparation of local alcoholic beverages, there are a few examples of this procedure being used to prepare local weaning foods with low dietary bulk (Hellström et al. 1981).

Background

The most common weaning food is a thin "uji" or porridge of maize or sorghum. Depending on season and area, a variety of beans, peas, and vegetables are added; most of the time, however, the early weaning diet is composed of single foods. With the exception of diets prepared in some pastoral communities, the fat content is very low, especially in the diets of the Masai, the Wasukuma, and the Wakuria. Generally, we can classify weaning foods in Tanzania into four groups:

- Weaning foods composed of single foods, usually cereal flours made into thin porridges or gruels ("uji");
- Double mixes, i.e., a mixture of cereal or root/tuber flour or bananas prepared as a mash, mixed usually with a little milk or animal fat;
- Triple mixtures of starch cereal, fruit, and vegetable mash; and
- Multimixes, including all the varieties mentioned, plus any other food that the mother finds suitable and that makes the food palatable and attractive.

As mentioned earlier, the majority of mothers in the country use weaning foods composed of a single type. Limited surveys in the country show that many children suffer from protein energy malnutrition (PEM). About 6-7% of children suffer from extreme PEM. This figure is very high. The normal average of severe PEM in those areas where malnutrition is said to be moderate is between 1 and 2% (TFNC 1987). PEM exists at these levels for several reasons: the diets of children as well as of adults are, on the whole, based on cereal staples, and have only limited supplementation with protein, vitamins, and mineral sources; this situation is exacerbated by inadequacies in the frequency of feeding, in the amount of food given per meal, and by the presence of disease.

Because of ecological, geographical, and other variables, there exist many weaning practices. The "uji" feeding method is used in almost every part of the country. Some children are fed only once or twice a day - a feeding frequency that is inadequate for young, growing children. We must make it a priority to discover ways of increasing the number of times a child is fed.

The timing of the initiation of weaning is extremely important. According to the population census of 1978 in Tanzania, the child mortality rate is around 231/1000. Those children whose resistance to disease is lowered not only suffer loss of strength, but also have difficulty performing well at school. The issue of energy density must also be addressed in this workshop: it is one of the major constraints in child feeding for most of the developing world. Most foods given to children have low energy density (dietary bulk). The problem of dietary bulk in children's meals is discussed in the following section.

Use of Additives

The addition of fats, oils, or sugar has some influence on the consistency of the food. Fats and oils have been found to have a double effect on the bulkiness of a diet. First, they lower the viscosity of a gel by interfering with the formation of the gel network. Second, fat has a higher energy density: 1 g of fat produces 9 kcal, whereas carbohydrates produce about 4.2 kcal/g (Cameron and Hofvander 1983). Furthermore, fats, unlike starch, do not bind with water when prepared in a porridge. With regard to a prepared porridge, fat is 10-15 times denser than starch (Svanberg 1985). Sugar has also been proven to decrease the gel (viscosity) strength. Although fats and sugar are excellent in reducing dietary bulk, the prices of these two commodities are extremely high in Tanzania.

Fermentation

Because of their heavy workload, most mothers lack the time to feed their children as frequently as is required. These mothers are able to feed their children, at most, three times a day. Fermentation of food can, however, make it possible to increase feeding frequency: fermentation of cereals breaks down the starch structure and reduces the water-binding capacity of the gruel or "uji"; as a result, fermented foods have a relatively long shelf life, do not require recooking, and can be served anywhere. The Waarusha, Wamasai, and Wameru of northern Tanzania feed their children with a fermented food known as "loshoro" - a liquid food mixture made from well-cooked dehulled maize, fresh milk, bananas, and a small amount of fermented milk. "Loshoro" can last for 2-3 days without spoilage and does not need recooking; mothers can therefore feed their children as many times per day as they wish. Such good examples need to be emulated and improved upon.

Cereal fermentation for child feeding is becoming less common among many tribes in Tanzania. Traditionally, a number of these tribes prepared "togwa" - a fermented porridge made from cereal flour and served as a drink to children and to adults. This good practice is gradually disappearing; there is a need to revive it before it disappears altogether. At present, fermentation of cereals in Tanzania is used mainly for the brewing of local beverages.

Material and Methods

Because sorghum is drought-resistant and is already widely used for germination (primarily for the preparation of locally brewed beer), it is the main cereal included in this study. The study used one of the traditional and one of the improved varieties of the white (low tannin) type of sorghum; the others were brown (high tannin) types. Their respective generic names are traditional (local) white "Lugugu" and brown "Udo Msonga," and improved white "ET-35" and brown "5DX 135/13/3/1." In addition to the sorghum varieties, one type of maize (Ilonga white composite) - a white "flint" maize variety - was also studied.

In this study, all the sorghum and maize flour used for preparing the gruels had been milled (whole grains) in a laboratory plate mill (80% passing a 60-mesh sieve), either with or without prior germination.

Germination

The traditional germination procedures at the village level in Tanzania were adapted to laboratory conditions as follows: the seeds were soaked in 70% ethanol for 2 min to prevent the growth of microorganisms. The seeds were then soaked in the same amount of water and kept in the dark for 12-20 h. After being washed in distilled water, the seeds were spread in a layer 1-cm thick between wet cotton cloths, and left to germinate for 48 h at room temperature (20°C). The sprouted seeds were dried on a plate in an air stream at 50°C, and the dried seeds with their vegetative portion were milled in the laboratory mill.

With traditional germination, the grain was thoroughly washed, soaked in the excess water overnight, and washed again. The soaked grain was thinly spread in a gunny bag, placed flat on a clean floor in the house, and covered with grass to maintain darkness. The bag was sprinkled with water daily and germination was allowed to continue for 2 days. The germinated cereal flour was termed "power flour" (P.F.) by the author.

Preparation of Gruels and Viscosity Measurement

Flour and distilled water were mixed in a glass beaker and heated in a boiling water bath to reach a cooking temperature of 95°C within 7-10 min; the mixture was then left at room temperature to cool. Gruels were prepared either from ungerminated or germinated flours, or from ungerminated flour mixed with 5-10% germinated flour (added before or after cooking).

The viscosity of the gruels was measured using a Haake Rotovisco model RV1 with an SCII profiled measuring system and a shear rate of 54 rpm. The measuring temperature was kept at 40°C to allow comparisons of different types of gruels. Lower temperatures are commonly used for feeding infants, and this usually means higher viscosities. Household viscosity measurements were carried out using a Brookfield Viscometer.

Germinated Cereal Flour Adoption

In 1983, a group of scientists led by Dr Alexander Mosha at the Tanzania Food and Nutrition Centre (TFNC) conducted a study on germinated cereal flour in Luganga village in the Iringa region. Many tribes in Tanzania use the germination of cereals for brewing the local beer; as far as brewing was concerned, therefore, the process (germination) was not a new one for many mothers. It was, however, a new concept as it related to the germination of cereals for porridge-making.

The objective of the study, as expressed by Mosha (1985), was to determine the acceptability for mothers of bulk-reduced "uji," their readiness to use the technique, and the actual intake of this porridge by young children. This paper highlights the general methodology used during the study, and the promotion of the use of P.F. in other parts of the country. In conducting the exercise, 40 households were selected randomly. These households represented all the village administrative cells. From each of the selected households, young children were chosen and their weights recorded monthly for 10 months.

Before the P.F.-treated porridge was fed to the children, it was served to the mothers: young children will usually eat what their mothers will eat. Porridge containing 20% flour was cooked for 30 min, cooled to 40°C, reduced in bulk by the addition of germinated flour, and served to the mothers. The mothers were asked to score their reactions on a hedonic scale score sheet. The parameters considered were smell, colour, taste, texture, and readiness to feed this type of food to their children. The scale ranged from 5 (very good) to 1 (very bad), as described in the Indian Standard of 1972 (Mosha 1985). The research team interviewed mothers who couldn't read and write, and helped in marking the scores. The acceptance and use of P.F. in the household was recorded by mothers who participated in the food intake study; this study continued for 3 months.

Results and Discussion

Figure 1 shows the viscosities of gruels prepared from different amounts of ungerminated and germinated flours (5-25% counted as dry matter). All the ungerminated flours had very similar concentration viscosity relationships: a suitable eating consistency for small children (1000-3000 cP) is obtained with gruels containing about 10% flour.

With germinated flours, large differences were observed among the varieties studied. For the improved white sorghum variety and for the maize, the amount of flour in the gruels can be increased considerably (2-3 times) before the viscosity becomes unacceptably high. This is evidently a result of starch degradation caused by the action of the alpha- and beta-amylases that develop during germination.

For the improved brown sorghum variety, however, germination for 48 h had no observed effect on the concentration/viscosity relationship. The amylolytic activity obviously developed more slowly in the high-tannin sorghum variety. The explanation for this may be the inhibitory effect exerted by the tannins on the activity of amylolytic enzymes in the seed (Ljungqvist et al. 1981).

Figure 2 shows how, when the thick gruels were cooled to 40°C after cooking, their viscosities were affected by the addition of germinated flour. Before this addition, the flour gruels prepared from

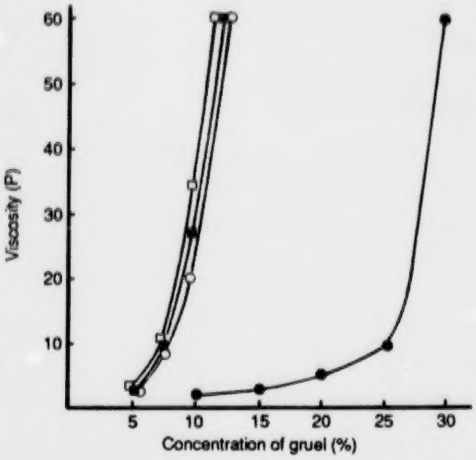

Fig. 1. Viscosity curves of various gruel concentrations of ungerminated and germinated grains. (□) SDX, ungerminated; (■) SDX, germinated; (○) ET-35, ungerminated; and (●) ET-35, germinated.

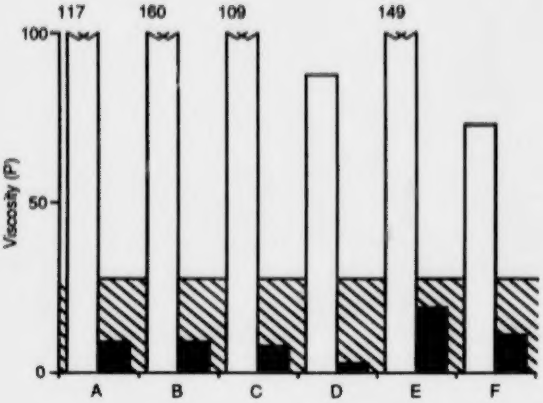

Fig. 2. Viscosity of gruels with ungerminated flour, concentration 15% at 40°C (□); after addition of germinated flour at 40°C and viscosity measured after 10 min (■). ▨, acceptable eating consistency for children of approximately 1-3 years. A, local, ungerminated white sorghum; B, improved, ungerminated white sorghum; C, local, ungerminated brown sorghum + local, germinated white sorghum; D, improved, ungerminated brown sorghum + local, germinated white sorghum; E, local, ungerminated maize; F, sun-dried, ungerminated cassava + germinated maize.

ungerminated sorghums (15% dry matter) had viscosities ranging from 9000 to 16,000 cP at 40°C; these figures represent very thick consistencies. With the addition of a small amount of germinated flour of the white (low-tannin) sorghum varieties, the viscosity decreased within 5 min to below 1000 cP; this represents a semiliquid consistency, suitable for child feeding. Only about 5% addition (based on the total amount of flour) of germinated flour was required for this effect. The same effect was observed when germinated maize flour was added to ungerminated maize flour gruel.

To determine the heat sensitivity of the amylolytic enzymes in the germinated flours, additions were made at different temperatures. Figure 3 shows that the germinated flour can be added at any temperature between 20 and 70°C with the same viscosity-reducing effect as that described earlier for 40°C. Above 70°C, the enzymes seem to be inactivated by heat; some activity (40%) remained, however, even at 90°C.

Germinated flour of the white (low-tannin) sorghum varieties that had been prepared in the villages was also tested in this experiment, and gave the same results as the laboratory-germinated flour described earlier. In this case, however, some mouldy seeds were observed; in practical applications, these should be removed to avoid mycotoxin hazards. If the microbiological quality of the added germinated flour is questionable, the gruel can be reheated to boiling temperature after time has been allowed for enzyme activity. This will not affect the viscosity and will destroy cyanide activity (Brandtzaeg et al. 1981).

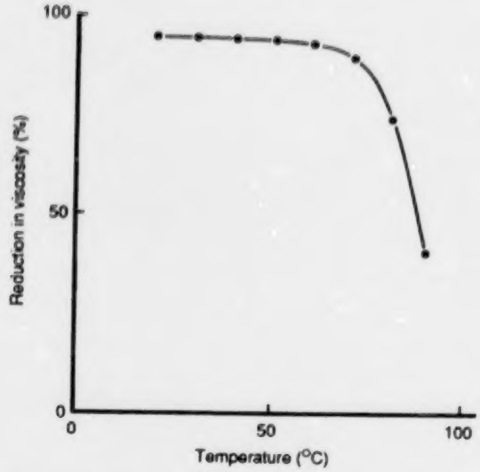

Fig. 3. Reduction of viscosity by adding germinated flour to gruels of ungerminated flour (15% concentration) at different temperatures.

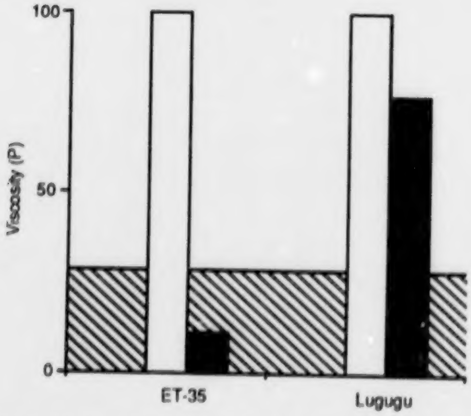

Fig. 4. Viscosity of sorghum gruels with germinated flour added immediately before cooking (□) and after soaking overnight before cooking (■). ▨, acceptable eating consistency for children 1-3 years old.

Figure 4 shows that when germinated flour was added to ungerminated flour immediately before cooking the gruel, no viscosity-reducing effect could be observed. In this case, a 10% addition of germinated white sorghum flour was used.

Figure 4 also shows the effect of leaving the mixtures of ungerminated and germinated flours (90:10) to soak in water overnight before cooking. Here the amylolytic activity of the germinated sorghums was evidently effective. The gruels prepared from these soaked flour mixtures had markedly reduced viscosities, measured at

40°C. If this approach to producing low-density gruels is considered, it becomes important to select varieties that will give the desired effect. When only ungerminated flour was left to soak overnight before cooking under ordinary laboratory conditions, no viscosity reduction was observed.

The mothers readily accepted the bulk-reduced porridge. On average, about 30% of the mothers indicated that they were using P.F. almost every time weaning food was prepared; the rest were using P.F. 25-50% of the time.

In the studies comparing children's intake of porridge with and without P.F., the following procedure was followed once each month: on the 1st day, the children were given porridge with 5% flour; the 2nd day, they were fed porridge with 20% flour but without P.F.; and on the 3rd day, they received porridge with 20% flour, treated with P.F.

On the whole, there was a wide variation in individual food intake within age groups. Children between 12 and 24 months (the critical age during weaning) had a range of 277 ± 93 g mean porridge intake per meal for 20% solids porridge without P.F., to 347 ± 94 g for the bulk-reduced porridge (Mosha 1985). In other words, the intake of P.F.-treated porridge was more by 25% than the intake of stiff porridge of the same concentration. There was no significant variation between intake of porridge with 5% solids (liquid) and that with 20% solids treated with P.F.

Fieldwork

The acceptability of bulk-reduced white maize porridge, thinned by the addition of P.F., was tested with eight mothers. The parameters used included colour, smell, taste, texture, and readiness to feed the porridge to their children. The scores averaged "very good," indicating favourable acceptability.

The adoption of P.F. by mothers in 40 households over a test period of 3 months is summarized in Table 1. The group using P.F. "every time weaning food was prepared" doubled. The proportion of those using it 25% or more of the time increased from 48 to 86%. These findings were later used as a basis for a regional campaign to promote bulk-reduced gruels.

Table 1. Adoption of "power flour" (P.F.) by mothers for preparation of weaning food in 1983 (%).

Use of P.F.	April	May	July
Almost every time	12.5	17.5	27.5
50% of the time	15.0	15.0	22.5
25% of the time	20.0	25.0	35.0
Several times	35.0	30.0	10.0
Do not remember	17.5	12.5	5.0
Total	100.0	100.0	100.0

Table 2. Effect of added power flour (P.F.) on the viscosity of gruels prepared by mothers at home (maize gruel plus 5% groundnuts).

Household number	Viscosity of household gruels[a] (cP x 1000)		Temperature (°C)	Solids (% w/w)
	Without P.F.	With P.F.		
1	120.0	10.0	38	18
2	240.0	5.0	50	23
3	280.0	7.0	43	25
4	170.0	4.0	42	18
5	80.0	1.5	38	15

[a] Viscosity for the samples with P.F. was read at a temperature of about 2°C below the sample without P.F. A spindle speed of 2 rpm was used for all the determinations.

Table 2 summarizes the effect of maize P.F. on the viscosity of gruels prepared by mothers, using ordinary maize flour and 5% groundnut flour. The treated gruel was, on average, 40 times rheologically thinner than the control; this promises easier ingestion and greater nutrient intake, and accords with other investigations using sorghum and finger millet (Hellström et al. 1981; Mosha and Svanberg 1983; Mosha 1984).

Food intake by preschool children was considered for only 18 children, aged 12-48 months (the period when malnutrition is usually at its worst). On average, 50% of the children ate 440 g of the thin 5% solids porridge during one meal. The liquid bulk-reduced 20% solids porridge averaged 390 g/child per meal for 50% of the group; the 20% solids untreated thick porridge averaged only 220 g/child per meal. This indicates that in real terms, nutrient ingestion was four times greater with the bulk-reduced porridge than with the untreated thin gruel, and twice as much as with the thick untreated porridge. The amounts are within the range of results reported by other investigations on young children (Ljungqvist et al. 1981; Mosha and Svanberg 1983).

After 10 months of the Luganga study, in December 1983, a Joint Nutrition Support Programme (JNSP) was launched in Iringa by UNICEF and the World Health Organization (WHO), in collaboration with the Tanzanian government. The JNSP program was preceded by a mass campaign that covered 168 villages; about 60,000 children under 5 years of age were reached. The campaign centred around four important aspects of child survival and development: growth monitoring, oral rehydration therapy, breastfeeding and weaning foods, and immunization. The four aspects were known by the acronym GOBI. Under the aspect of breastfeeding and weaning foods, six practices were advocated:

- Breastfeeding the child for a long period (at least 1.5 years);
- Increasing the frequency of feeding;
- Preparing high-density food (thick porridge) whose thickness is then reduced by the use of P.F.;

- Using multimixes to achieve nutrient complementarity;
- Providing enough food per meal; and
- Maintaining hygienic conditions during preparation as well as during feeding.

The response in terms of a willingness to use P.F. was very positive. As was mentioned earlier, although most mothers knew how to prepare germinated cereals for brewing purposes, they did not know how to use P.F. to thin down the thick porridge. Because the procedure is not difficult, however, they easily adopted the technique.

During the campaign in each of the 168 villages, those children who were seriously malnourished were identified; their parents were then asked to take them to established feeding centres daily. At the feeding centres, the children were fed thick porridges, thinned down by P.F. The feeding was carried out by the mothers, with daily assistance from village health workers.

For the Iringa region, the application of P.F., together with other nutrition programs, had a significant effect: the child mortality rate was reduced from 152/1000 to 107/1000 by 1986. The project has also reached Mtwara, Ruvuma, Morogoro, Singida, Kilimanjaro, Arusha, and Kagera - 7 out of 20 regions, and still in progress.Over 20 radio programs have been broadcast on the use of germinated cereal flour.

Conclusions

Other researchers have reported the viscosity-reducing effect of germinated cereals in the preparation of gruels for infants and small children (Hellström et al. 1981; Mosha 1984); this effect is also recognized in a number of traditional communities. Considering the fact that the technology and raw materials are common in most village situations, one might ask why this beneficial practice is not more widely used. An answer may lie in the time-consuming nature of the operation; given the already heavy work load of the women, new and lengthy tasks may not be readily accepted. The proposed method of using germinated flour as an additive to liquefy weaning gruel may, however, still be a viable option: germinated flour requires less frequent preparation, and small portions can be set aside when the local beer is produced.

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CHILD FEEDING PATTERNS IN TANZANIA WITH REFERENCE TO FEEDING FREQUENCY AND DIETARY BULK

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Abstract *This paper reviews the data from food intake studies of young children in Tanzania. The purpose of such a review is to assess the relative importance of factors such as feeding frequency and type of food, in relation to feeding adequacy. The analysis shows that feeding frequency is by far the most important factor in determining adequate energy content in the diets. For children under 24 months of age, stiff porridge ("ugali") seems to offer advantages not found with meals based on rice or tubers. Two separate feeding trials provide evidence on the potential of germinated cereals to increase the dietary energy of soft porridges, and thus to improve energy intake for healthy and for sick young children.*

Protein energy malnutrition (PEM) in Tanzania is a major public health problem, and one of the direct causes of the high infant and child death rates observed (UNICEF 1985). Available information shows that 40-60% of children under 5 years of age have a weight-for-age below 80% of the Harvard standard; 4-6% are below 60% of the same standard (UNICEF 1985).

The main dietary reason behind these high levels of PEM in Tanzania is inadequate intake of "total food," or energy; the nutrient content per energy unit is usually found to be satisfactory (Sheshamani 1981; Lukmanji 1985). The following three factors were observed by Ljungqvist (1988) to be determinants of low total food intake:

- Low feeding frequency during the weaning and postweaning stages;
- Insufficient dietary therapy during and immediately after the mild and severe illnesses that frequently occur; and
- The low energy density of the diet, due to high dietary bulk.

The low feeding frequency is primarily a result of the mothers' heavy work load; these mothers are left with little time to prepare food and to feed their children. In many cases, the problem is exacerbated by poor availability of food and fuel, and by a lack of proper facilities for food preparation in the households.

Constraints on the mothers' time also make difficult the proper feeding and care of sick children. Because of insufficient awareness of and attention to this factor by health workers and by the caretakers themselves, the full potential of food intake during illness and convalescence is not realized.

The low energy density of the diet is a result of the high starch content of the foods consumed. The amount of fats or foods of animal origin in the children's diet is usually very low. As a result, the food given to the children is high in "dietary bulk" (Ljungqvist et al. 1981); this means that even when they fill their stomachs, the children will consume very little dietary energy at each meal. The use of germinated cereals has recently attracted attention as a means of overcoming the problem of dietary bulk in child feeding (UNICEF 1987). This technique could have great potential for the situation in Tanzania: germination of cereals is already widely practiced throughout the country, usually in the preparation of local beer; in some instances, these germinated cereals are also in use for child feeding.

Methods and Materials

Review of Food Intake Studies of Children

A number of food intake studies of young children have been conducted in Tanzania. The results of these studies are usually presented in terms only of total daily intakes of energy and nutrients. This makes it difficult to assess the relative importance of feeding frequency, dietary bulk, food composition, and other feeding factors in relation to total feeding adequacy. For some of these studies, however, the original data were available in the archives of the Tanzania Food and Nutrition Centre; this allowed a more detailed analysis of the above-mentioned factors.

The studies selected for the analysis all used a "weigh and record" methodology, whereby the following weights were recorded: that of the raw ingredients of the dish prepared for the child or for the whole family; that of the total prepared amounts of each dish of the meal; and that of the actual amount of each dish consumed by the child.

The total energy, fat, and protein content of the meals, and the child's intake of these nutrients, were then calculated by using food tables (Platt 1962). Other relevant information was collected, such as the age and sex of the child, and the type of meal (breakfast, lunch, evening meal, or snack).

The studies initially entered into the system were all carried out in village households. The children were followed for 3-4 days by an enumerator who stayed throughout the day with the family. The studies covered the regions of Iringa, Mbeya, and Morogoro. The total number of child-intake days came to 254, with a total of 445 individual meals, involving 100 children under 5 years of age.

Community Food Intake Trials

The child-feeding trials were carried out in two locations (Ifupira village and Stone Valley Tea Estate) in Iringa Region; at the same time, the household "weigh and record" diet survey was being conducted. The children were gathered at the respective sites and fed different porridge formulas. The trials were initially intended for children 12-36 months of age; their older and younger siblings arrived with them, however, and were included in the trial. In Ifupira village, the trial was carried out for 3 days, and in Stone Valley, 1 day. Although 75 children had been expected to take part daily for 3 days, only 17-28 children attended in the Ifupira village feeding trial. On the first 2 days, these children were divided into two groups, one receiving plain maize porridge and the other receiving maize porridge with added germinated flour. On the 3rd day, all the children received stiff maize porridge ("ugali") with relish.

In the Stone Valley trial, 69 children participated. They were randomly divided into 3 groups, and each group was fed either on fluid porridge or on stiff porridge: the 1st group was given maize porridge; the 2nd group, maize porridge with germinated flour; and the 3rd group, maize stiff porridge with relish. The composition of the maize porridge without germinated flour was as follows: maize flour (70 g/child); sugar (20 g/child); groundnuts (10 g/child); and water (800 mL/child). The maize porridge with germinated flour included the following ingredients: maize flour (70 g/child); sugar (20 g/child); groundnuts (10 g/child); water (400 mL/child); and germinated millet flour (5-10 g/child). The germinated flour was added after the porridge had been cooked and cooled to a temperature suitable for consumption, as described by Mosha and Svanberg (1983). Before these two porridges were served, it was ensured that both had the same consistency. The maize stiff porridge consisted of maize flour (100 g/child) and water (300 g/child). About 200 g of each of the two porridges were served to the children. Any leftover or extra helpings were weighed.

About 300 g of stiff porridge ("ugali") was served with a relish prepared from pumpkin leaves, tomatoes, and onion, with a little oil added. The contribution made by the relish to the total food and energy intake was not recorded: there was too great a problem in measuring exactly how much of this relish was consumed. Earlier studies have shown that because of the way in which children are fed the relish, it provides very little extra food or energy.

Results and Discussion

Review of Food Intake Studies

The data from the food-intake studies will be reviewed according to the framework proposed by Ljungqvist (1988). This framework defines the daily energy and nutrient intakes of children as functions of the following factors: number of meals per day, amount of food consumed per meal, energy/nutrient density of the prepared meal, and bioavailability of the energy/nutrient. An assessment of feeding inadequacies according to these factors will help to identify crucial underlying causes of problems and direct corrective measures.

Table 1 shows the number of meals provided per day. The vast majority of the children received two meals a day; many were given only one meal. There was no difference in feeding frequency between the age groups. Three children did not receive any meals on the days studied; although it is likely that they were breastfed, the records do not provide reliable information on this.

Apart from the meals shown in Table 1, snacks given to the children between meals were also recorded. In all the 254 days of child intake records, however, snacks were given only 17 times. They consisted mainly of roasted maize or cashew nuts.

Table 2 shows the average amount of food and the energy intake consumed by the children at each meal. It is clear that although both the amount of food consumed and the energy intake increase with increasing age, the average amount of food consumed at each meal and the corresponding energy densities (Table 3) may be assumed to be slightly high.

This may be attributed to discrepancies arising from the survey methodology itself: because no food composition tables were available for raw foods, the cooked food intake data obtained through weighing had to be converted to the equivalent for raw foods; some families felt that because of the diet survey, they had to eat at certain times; and the meals consumed in the evening were often difficult to weigh in inadequate light.

Table 3 gives the energy densities of the meals consumed by the children. These energy densities were almost the same for all age groups, indicating that very similar types of meals are consumed

Table 1. Number of children of different ages fed 0-4 meals per day.

Age (months)	Number of meals					Total
	0	1	2	3	4	
6-12	1	3	6			10 (2.2)[a]
13-24	2	20	71	4	3	100 (22.5)
25-36	-	19	113	23	-	156 (35.1)
37-60	-	32	135	12	-	179 (40.2)
Total	3 (0.8)	74 (16.6)	325 (73.0)	39 (8.8)	3 (0.8)	445 (100.0)

[a] Figures in parentheses are percentages of total.

Table 2. Total food intake and energy intake per meal in children of different ages (mean ± SD).

Age (months)	Total food intake (g/meal)	Total energy intake (kcal)	No. of meals
6-12	179 ± 96	288 ± 166	10
13-24	284 ± 183	330 ± 210	100
25-36	343 ± 168	406 ± 220	156
37-60	448 ± 233	520 ± 223	179

throughout early childhood. It is most often the case that the children feed on the same foods as that eaten by the adults. A high energy density is observable in the food consumed by the youngest age group (6-12 months); this may be due to the fact that these meals were, in a few instances, rich in fat.

Table 4 shows the total daily energy intakes of the children studied. In all the age groups, the observed energy intake is well below recommended allowances. Unfortunately, there was no reliable information in the study records regarding breastfeeding. Other studies conducted under similar conditions have shown that 80-90% of children stop breastfeeding between 12 and 24 months. This probably means that when breastfeeding is stopped, there will be an abrupt decrease in energy intake.

Table 5 shows the total daily energy intake in relation to feeding frequency. Table 6 shows the amount of food eaten per meal, in relation to feeding frequency. From these tables, it is clear that the amount consumed in each meal does not differ very much if one or two more meals are given. There is some evidence that those children between 25 and 60 months of age can compensate by eating more when they are fed fewer meals. In general, however, total daily intake is strongly related to the number of meals eaten. It can be concluded that under the given circumstances, feeding frequency is by far the most important factor determining adequacy of energy intake.

Table 3. Energy density in meals of children of different ages (mean ± SD).

Age (months)	Energy density (kcal/g prepared food)	Number of meals
6-12	1.40 ± 0.64	10
13-24	1.19 ± 0.40	100
25-36	1.19 ± 0.34	156
37-60	1.22 ± 0.29	179

Table 4. Total daily energy intake (mean ± SD) in children of different ages.

Age (months)	Total energy intake (kcal/day)	Number of days
6-12	479 ± 185	6
13-24	523 ± 463	29
25-36	665 ± 397	50
37-60	833 ± 393	169
Total		254

Table 5. Total daily energy intake (kcal) in children, according to number of meals per day for 254 food-intake days (mean ± SD).

Age (months)	Number of meals per day 1	 2	 3 + 4
6-12	427 ± 59 (3)[a]	532 ± 272 (3)	0
13-24	195 ± 253 (14)	768 ± 389 (13)	1236 ± 257 (20)
25-36	403 ± 203 (11)	734 ± 425 (34)	772 ± 310 (5)
37-60	513 ± 225 (53)	964 ± 345 (106)	1156 ± 530 (10)

[a] Number of days is given in parentheses.

Table 6. Food consumed per meal (g) by children receiving a different number of meals per day for 254 food-intake days (mean ± SD).

Age (months)	Number of meals per day 1	 2	 3 + 4
6-12	233 ± 31	182 ± 63	0
13-24	220 ± 178	361 ± 198	372 ± 64
25-36	358 ± 151	306 ± 179	212 ± 73
37-60	449 ± 174	402 ± 173	357 ± 139

We will now consider in more detail the types of diet consumed in relation to the total energy intakes of the children. The meals given to the children were classified according to consistency: "solid" (rice and tubers), "semisolid" (stiff porridge, or "ugali"), and "liquid" (soft porridge, milk, and tea). When foods were combined, the dominant component of the meal (in terms of amount) determined the classification.

Table 7 shows the energy density of the meals according to consistency. It is clear that there is only a small difference between solid and semisolid meals; the liquid meals have a much lower energy density.

Tables 8 and 9 give the total food intake and the total energy intake per meal, respectively, for foods of different consistencies. It is interesting to note that compared with meals of solid consistency, semisolid meals are higher in total food as well as in total energy intake. This difference is significant only for the youngest age groups; for children 6-24 months of age, therefore, there would seem to be a clear advantage in providing stiff porridge ("ugali") with relish, rather than meals based on rice or tubers. Meals of liquid consistency provide much less energy per meal than do those of solid or semisolid consistency.

The fat content of the meals was also analyzed. It was found that in the vast majority of the meals (89%), there is scarcely any fat at all. Only 6% of the meals contained significant amounts of fat

Table 7. Energy density of prepared food for meals of different consistencies (mean ± SD).

Consistency	Energy density (kcal/g)
Solid	1.29 ± 0.38 (264)[a]
Semisolid	1.14 ± 0.33 (167)
Liquid	0.28 ± 0.19 (8)

[a]Number of observations is given is parentheses.

Table 8. Total food intake in children given meals of different consistencies (mean ± SD).

Age (months)	Solid	Semisolid	Liquid
6-12	261 ± 162 (5)[a]	393 ± 62 (4)	- (0)
13-24	322 ± 209 (67)	388 ± 190 (29)	30 ± 18 (4)
25-36	423 ± 229 (96)	431 ± 194 (55)	138 ± 109 (3)
37-60	533 ± 244 (99)	508 ± 188 (79)	484 (1)

[a]Number of children studied is given in parentheses.

Table 9. Total energy intake (kcal) in children given meals of different consistencies (mean ± SD).

Age (months)	Solid	Semisolid	Liquid
6-12	187 ± 104 (5)[a]	214 ± 31 (4)	-
13-24	262 ± 188 (67)	343 ± 169 (29)	225 ± 61 (4)
25-36	330 ± 164 (96)	377 ± 171 (55)	265 ± 129 (3)
37-60	445 ± 275 (99)	456 ± 168 (79)	145 (1)

[a]Number of children studied is given in parentheses.

Table 10. Protein content per energy unit in meals with different consistencies, expressed as percentage of energy provided by proteins (mean ± SD).

Consistency	Protein/energy (%)
Solid	13.4 ± 6.4 (264)[a]
Semisolid	11.0 ± 3.5 (167)
Liquid	21.5 ± 39.8 (8)

[a]Number of observations.

(10 g or more) in the form of coconut milk, cashew nuts, unprocessed seeds, or cooking oil.

The protein content of the meals, expressed as percentage protein/energy, is given in Table 10. In the meals with solid or semisolid consistency, the energy provided by protein was 13.4 and 11.0%, respectively. In meals based on rice or tubers, the intake of relishes was higher, thus providing some extra protein. The liquid meals had a higher percentage protein/energy (21.5); this may be because tea with milk was classified as a liquid meal.

Community Food Intake Trial

The total intakes in the child-feeding study in Ifupira and Stone Valley are summarized in Table 11 below. It is evident that there is no significant difference between the intake of plain porridge and that of porridge with germinated flour. The intake of stiff porridge is, however, higher in all age groups.

It is possible that the feeding procedure, in which the children were offered first 300 and then 200 g of food, may have aimed at having them finish what they were served and feel satisfied. This is further indicated by the fact that many of the actual intakes are clustered around these amounts. Because, however, the sample size was small and other factors affecting a child's food intake were not considered, no firm conclusions can be drawn.

For the 2 younger age groups, the amounts consumed increased slightly by age for the 3 preparations tested. No differences in intake according to sex or nutritional status (weight-for-age) were found with any of the preparations or age groups.

The intakes of energy and protein from the same meals are given in Table 12. The concentration of energy and protein per unit of prepared food is twice as high in the porridge with germinated flour as in the untreated porridge. Given an equal consumption of both types of porridge, the energy and protein intakes are therefore also about twice as high when germinated flour is used. The energy and protein concentrations in the stiff porridge are even higher than those in the preparation with germinated flour; moreover, higher amounts of the stiff porridge were consumed. Energy and protein

Table 11. Average intake of children receiving three different types of food based on maize flour.

Age (months)	Plain porridge (g)	Porridge with germinated flour (g)	Stiff porridge (g)
6-12	128 ± 55 (4)[a]	135 ± 84 (6)	185 ± 163 (2)
13-24	150 ± 85 (15)	166 ± 64 (15)	223 ± 80 (9)
25-36	151 ± 57 (11)	176 ± 65 (11)	300 ± 0 (8)
37-60	169 ± 67 (11)	172 ± 106 (14)	222 ± 92 (12)

[a] Number of children.

Table 12. Average intake of energy (kcal) and protein (g) of children receiving three different types of food based on maize flour.

Age (months)	Plain porridge		Porridge with germinated flour		Stiff porridge	
	Energy (kcal)	Protein (g)	Energy (kcal)	Protein (g)	Energy (kcal)	Protein (g)
6-12	54.6	1.0	114.7	2.0	200.4	4.8
13-24	64.0	1.2	141.0	2.5	248.2	5.8
25-36	65.0	1.2	150.0	2.6	334.0	8.0
37-60	72.0	1.3	154.7	2.7	247.0	5.8

intakes with the stiff porridge were therefore about twice as high as those from the porridge with germinated flour, and about 4 times as high as those from plain maize porridge. It may be noted that all the children who participated in this study were apparently healthy, and were accustomed to eating stiff porridge with relish.

Food Intake of Hospitalized Children

The intakes of hospitalized children are given in Table 13. The researchers studied children who had been admitted to the pediatric unit of a hospital in Morogoro Region. The established schedule of this unit already included feeds of porridge with and without germinated flour. Every day at 0800, the children were fed maize porridge with germinated flour added after cooking; at 1100, they received maize porridge with dried, ground fish added. The total intake for 1 day of both porridges was weighed. On the morning of the following day, sugar was added to the porridge with germinated flour, to test whether the sweeter taste would lead to a higher intake.

The composition of the three types of porridge was as follows:

- 1st day - Porridge with germinated flour was given at 0800 (30 g maize flour/100 g prepared porridge, with a small amount of germinated flour added after cooking) (Mosha and Svanberg 1983);
- 1st day - Porridge with fish was given at 1100 (10 g maize flour/100 g prepared porridge; 5 g dried, ground fish/100 g prepared porridge); and

Table 13. Intake of three types of maize-based porridge by hospitalized children (mean ± SD).

Age (months)	Porridge with germinated flour (g)	Porridge with germinated flour/ sugar (g)	Porridge with fish (g)
5-15	70 ± 45 (23)[a]	72 ± 41 (20)	81 ± 22 (19)
16-48	107 ± 45 (11)	95 ± 29 (8)	87 ± 19 (9)

[a] Number of children given in parentheses.

- 2nd day - Porridge with sugar was given at 0800 (30 g maize flour/100 g prepared porridge; 7 g sugar/100 g prepared porridge, with a small amount of germinated flour added after cooking).

The three porridges had a similar consistency when served to the children.

The ingredients were weighed by the ward nurse, and the porridges were cooked by two mothers under the supervision of the nurses. All children were weighed, and their clinical condition diagnosed by the pediatrician in charge. A total of 41 children were included in the study. Because of the turnover (admitting and discharging) of children in the ward, however, only 23 received all three types of porridge. The average amounts consumed by the children were quite small for all three types of porridge. It seems that adding sugar to the porridge did not improve the intake. For two of the three types of porridge, significantly higher amounts were consumed by the older age group.

Table 14 gives the energy and protein intakes of the meals presented in Table 13. It is clear that the addition of germinated flour helps to achieve similar protein intake levels as supplementation with fish flour. It was found, however, that the germinated flour preparations provide about twice the amount of energy. The addition of sugar to the germinated flour porridge increases the energy intake still further.

Table 15 shows the difference in intake between children with diarrheal diseases and those with other illnesses (primarily pneumonia, anemia, and tuberculosis). All 23 children included in Table 15 consumed the 3 types of porridge. There seems to be a reduced intake of porridge during acute diarrhea, as compared with the other illnesses; the differences are, however, small.

Table 16 shows that although the amounts of porridge consumed do not vary much for the 3 types, the energy and protein content can be increased by the addition of germinated flour and sugar. At this stage, however, one cannot be certain as to the impact of power flour porridge on child growth: we need to consider both the intake of other foods and the effects of associated factors. Further studies are warranted, involving larger samples.

Table 14. Energy and protein intake in hospitalized children from three types of porridge.

	Porridge with germinated flour		Porridge with germinated flour/ sugar		Porridge with fish	
Age (months)	**Energy (kcal)**	**Protein (g)**	**Energy (kcal)**	**Protein (g)**	**Energy (kcal)**	**Protein (g)**
5-15	75.6	1.7	94.0	1.7	41.5	2.0
16-48	115.0	2.6	128.0	2.2	44.0	2.0

Table 15. Total intake of three types of porridge in children with acute diarrhea and with other illnesses (mean ± SD).

	Porridge with germinated flour (g)	Porridge with germinated flour/sugar (g)	Porridge with fish (g)
Age, 5-15 months			
With diarrhea (9)[a]	62 ± 40	64 ± 23	82 ± 21
With other diseases (8)	85 ± 43	66 ± 31	84 ± 26
Age, 16-48 months			
With diarrhea (3)	95 ± 20	72 ± 25	78 ± 6
With other diseases (3)	113 ± 46	101 ± 39	106 ± 31

[a] Number of children.

Table 16. Protein and energy intakes of all three types of porridge for the amounts consumed, as indicated in Table 15.

	Porridge with germinated flour		Porridge with germinated flour/sugar		Porridge with fish	
	Energy (kcal)	Protein (g)	Energy (kcal)	Protein (g)	Energy (kcal)	Protein (g)
Age, 5-15 months						
With diarrhea	67	1.5	86	1.5	42	2.0
With other diseases	71	1.6	84	1.6	42	2.0
Age, 16-48 months						
With diarrhea	102	2.3	97	1.7	40	1.8
With other diseases	122	2.7	135	2.4	54	2.5

Conclusions

The review of the child intake data confirmed the direction of child survival and development planning and action in Tanzania. Feeding frequency seems to be the most decisive factor in determining energy intake and therefore feeding adequacy. Special meals for the children are primarily in the form of watery porridges; snacks are mainly of roasted maize. These are given very rarely, however, and do not contribute much to an improvement in dietary intake. Fat-rich food components are, moreover, seldom used in food preparations.

It is interesting to note that stiff porridge ("ugali") dipped in a relish seems to be more readily consumed by small children than are meals based on rice or tubers.

The computer-based system established for analyzing data on food intake for children can be further developed to include other factors such as breastfeeding, illness, and nutritional status. This system would then provide a very important means of assessing child-feeding adequacy under special conditions and circumstances.

The child-feeding trials included in this report investigate the means whereby soft porridges may improve the diet intake in healthy and in sick children. It seems that even when the children consume large quantities, the watery porridges sometimes prepared for them do not provide much in the way of energy or nutrients. The use of germinated cereals in the preparation of these porridges increases the energy and nutrient intakes by about 100%. This approach has great potential for child feeding, especially during acute illness, when food intake is reduced and liquid diets are often preferred.

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EFFECT OF FOOD CONSISTENCY ON NUTRIENT INTAKE IN YOUNG CHILDREN

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Abstract *Food intake measurements were performed on 31 children aged 8-56 months. The children were fed for 10 days with four test gruels of different consistencies: diet A - a soft gruel with 14% flour; diet B - a stiff porridge with 33% flour; diet C - a thick gruel, treated with germinated cereal flour or "power flour" (P.F.), with 27% flour; and diet D - a thick gruel (no P.F.) with 17% flour. For children under 3 years of age, food intake with diet A was significantly higher than that achieved with diets B, C, and D ($p \leq 0.01$); for children over 3 years of age, it was significantly higher with diet B only ($p \leq 0.05$). Children below 2 years of age ate significantly less with all the diets than did their older counterparts ($p \leq 0.01$). All children gained significantly more nutrients from diets B and C than from diets A and D ($p \leq 0.01$).*

For Tanzania, as for most developing countries, the problem of protein energy malnutrition (PEM) is the most serious nutritional problem affecting children, especially those of preschool age. The prevalence of severe PEM in this age group is, on average, 4-6%, and of moderate PEM, 40-60%. With both the severe and the moderate forms, the level of PEM is relatively low during the first 6 months of life. It then increases rapidly to peak between 1 and 2 years of age. From various Tanzania Food and Nutrition Centre (TFNC) reports, the same trend can be observed in Tanzania (Ljungqvist et al. 1978; Kisanga and Bunga 1983; Kavishe et al. 1984; Kingamkono et al. 1986). The infant and child mortality rate (12-17%) is also very high (Kimati 1977; Maletnlema 1986). About 10% of child deaths are attributable to severe PEM; a combination of disease and PEM accounts for 50% of all deaths (Kimati 1977).

Background

The following are the most immediate causes of deaths in children over 1 month of age: disease, and inadequacy in dietary intake and in nutrient utilization. The first 2 factors are directly related, in that one results in the other: most disease leads to anorexia, which immediately reduces intake. The presence, either singly or in combination, of any of these factors will likely result in malnourishment. In the case of severe malnourishment, there is usually a history of several diseases, and of acute or chronic low food intake.

Despite efforts to combat it, the problem of PEM has remained surprisingly constant over time and over geographical location. In the past, efforts were concentrated mainly on education: mothers were taught methods of weaning-food preparation (including the mixing of ingredients) that would balance the diet and increase feeding frequency. These approaches have met with little success: the mothers have an extremely heavy work load; they also have low purchasing power; and the problem of illiteracy exacerbates the tendency to ignore educational messages stressing the importance of frequent child feeding.

Dietary Bulk

Quantitative dietary surveys have revealed that although a diet may contain all the essential nutrients, it may still be difficult for the individual to satisfy his or her nutrient requirements (Ljungqvist et al. 1978). This is due to the high volume/viscosity characteristic referred to as "dietary bulk."

A diet that is high in bulk is common in most of the developing countries, where weaning foods are based mainly on starchy staples such as cereals and root crops. The most common weaning food in Tanzania is gruel ("uji"), made from the staple of the area. Depending on season and area, milk or a variety of beans, peas, and vegetables are added. In general, however, the early weaning diets are single mixes of starchy foods. As the child grows older, stiffer food ("ugali") is given. By the time the child is one year old, he or she is already eating from the family pot. Rarely is any special food prepared for younger children, and the feeding frequency is only 2-3 times per day.

The bulkiness of starchy weaning foods develops in the following manner: when cooked, starch granules break open and absorb water; they then swell, making the gruel thick; further interactions of amylose, amylopectin, starch granules, and water results in a gelatinization of the gruel (associated with the water-holding and -binding capacity of the starch granules) (Hellström et al. 1981). Not only are such gruels unpalatable, but they are also too viscous for the child to swallow; this leads to low food intake and, consequently, to low nutrient intake. To make such gruels thin enough to be of a suitable consistency for child feeding, large amounts of water must be added; this results in a dilution of the nutrients. Children have high nutrient requirements in relation to body size; their relatively small stomachs make it impossible for them to ingest enough of the thinned gruel to meet these nutrient requirements. Ljungqvist et al. (1981) found the problem to be even more pronounced for sick children, whose appetite is decreased, and whose food preference is shifted toward more liquid foods.

The bulk properties of starchy foods can be altered by various means, including the addition of fat, proteins, sugars, and salts; changes can be made in the levels of acidity; and processing methods, such as precooking, extrusion, enzyme treatment, and germination, can be introduced. In the poor rural areas, however, most of these approaches are limited by, among other things, the mother's low purchasing power. Only recently has the use of germinated cereal flour or "power flour" (P.F.) been considered for the reduction of dietary bulk in weaning foods; nutritionists became aware of the need for new approaches to the dietary bulk problem - approaches involving resources and technologies that would be available and applicable at the household level, and that would obviate the necessity of extensive preparation time. In one such new approach, P.F. - already widely used (mainly for brewing) in the rural areas of the developing countries - has been tested as a reducer of dietary bulk in starchy weaning foods (Mosha and Svanberg 1983; Svanberg et al. 1985; Mnjunju 1986).

In germinated cereal flours, advantage is taken of the amylolytic enzymes (developed during germination) to hydrolyze the starch granules into simple sugars that have a low water-binding and -holding capacity. During this stage, the gruel liquefies, making possible more solids per unit volume, while maintaining a thin consistency (Brandtzaeg et al. 1981).

Acceptability tests conducted in one village of Tanzania showed a high acceptance rate (more than 50%) for the use of P.F. Another study was conducted over a 6-month period to determine food intake for three test gruels of different consistencies, treated with P.F.; this study showed that viscosity affected food intake and was age-dependent (Mosha 1984). Because these studies were carried out over a long period during which environmental conditions varied considerably and the children grew older, it was felt that the results may have been biased. The conclusion was reached, therefore, that a more controlled food-intake study is needed.

This report presents the results of a food-intake study whose purpose was to determine the effect of consistency on food and daily nutrient intake at various ages. For purposes of comparison, a gruel treated with P.F. was included.

Methodology

The study was conducted in October/November 1986 at Ititi village in Singida region, central Tanzania, where the staple foods are maize, sorghum, and bulrush millet. A group of 31 normal, healthy children aged between 9 and 56 months were selected to participate in the study. (The study used the World Health Organization (WHO) method of anthropometric classification of individuals.) The mothers were then briefed on the purpose of the study, and their cooperation solicited. In order that the test diet be the first meal of the day, mothers were asked not to give any food to the participating children in the morning.

The study used four diets (each of a different consistency), representative of those commonly used for weaning purposes in rural Tanzania. The children were served diets A and B for 10 days, diet C for 7 days, and diet D for 3 days. Each diet was prepared daily, in one pot; the children were served from this pot once a day, at breakfast time (0900-1000). Mothers were involved in the preparation of the diets. Known amounts were served to the children ad libitum, and leftovers were weighed and recorded. Emphasis was placed on the maintenance of normal feeding patterns; to avoid bias in the results, similar conditions were maintained throughout the study period. Each morning before the meal, the mothers were asked to report any clinical conditions or symptoms that had been observed in the participating children.

Duplicate samples of each meal were sealed in polythene bags and frozen for nutrient density determination. Moisture content of meals was determined as per Horwitz (1975). Energy and protein content was determined by computation from nutrient composition tables of the ingredients. The data was subjected to statistical analysis using the Student-Newman-Keuls test.

The diets tested included the following:

- Diet A - soft gruel ("uji"), containing 14% dry matter, with sugar to taste;
- Diet B - stiff porridge ("ugali"), containing 33% dry matter, with sardines, "dagaa," or "mlenda." (The sardines or "mlenda" were prepared with peanut flour.);
- Diet C - thick gruel ("uji mzito"), treated with P.F. and containing 27% dry matter, with sugar to taste. After the gruel had been cooled to about 40°C, the P.F. was added and the mixture stirred until thin, and then reboiled; and
- Diet D - thick gruel ("uji mzito") without P.F., containing 17% dry matter, with sugar to taste.

Results and Discussions

Dry Matter, Energy, and Protein Content

Table 1 summarizes the mean dry matter, energy, and protein content of the diets. From this table, we see that diet A, a soft gruel, had the least amount of flour. This gruel was thin, with a runny consistency that thickened a little after cooling. Diet B, a stiff porridge, had the highest amount of flour and was very stiff, even when hot. Diet C, initially a very thick gruel, became thin after the P.F. was added, and very thin after reboiling; it thickened somewhat after cooling. Diet D, a thick gruel untreated with P.F.,

Table 1. Mean percentage dry matter, energy (kcal), and protein (g) in the diets.

	Diet			
	A	**B**	**C**	**D**
Dry matter	14	33	27	17
Energy (kcal)	50.1	118.2	96.5	60.5
Protein (g)	1.3	3.1	2.5	1.5

was semisolid even when hot, and the thickness increased even more when the gruel was cooled.

In other studies (Mosha 1984; Mnjunju 1986), it was observed that gruels made from ungerminated cereal flours reached a high consistency (above 3000 cP) at a very low solids concentration (12% solids). An acceptable consistency for gruels that are to be fed to children under 3 years of age falls below 3000 cP (Mosha et al. 1983). Because no viscosity measurements were taken in this study, it is difficult to quantify the viscosity of each diet. Diets A, B, and D in this study were made solely of ungerminated cereal flour; diet C, however, was made of a combination of 22% ungerminated flour plus 5% P.F. (germinated cereal flour). The behaviour of starch granules in boiling water has already been discussed. The thickness increases with the amount of flour, eventually resulting in a stiff porridge (diet B). The thinning of diet C - a diet containing a large amount of flour - is caused by amylolytic activities resulting from the addition of P.F.; during these activities, the starch granules are hydrolyzed into simple sugars that have a low water-holding and -binding capacity. Table 1 shows that the nutrient density (energy and protein) is directly proportional to the dry matter content of the diets.

Diets B and C contained about twice as much energy and protein as did diets A and D; this means that diets B and C were more valuable nutritionally. This observation is significant for the following reason: with diets B and C, smaller amounts of food, and probably fewer meals per day, will be required to meet the recommended daily allowance (RDA); to meet these requirements with diets A and D, however, consumption must be greater and more frequent. For the under fives, diets B and C are, therefore, the better choices: with these diets, children are able to meet their RDA within the limits of their stomach capacities and in fewer meals per day. The situation for diets A and D will be discussed in more detail later.

It should be remembered that in this study, sugar was used to increase the palatability of diets A, C, and D, and groundnuts were used to prepare the relish. It is not the purpose of this paper to discuss the benefits of sugar and groundnuts in increasing the energy and protein density of diets: in the rural areas, sugar is an expensive commodity, and groundnuts are grown mainly as a cash crop. In most cases, salt, rather than sugar, is used to increase the palatability of weaning foods. Dietary surveys conducted in Tanzania by TFNC have revealed that gruels made for weaning purposes have a very low energy density.

The thin gruels usually served to the younger children contain about 0.2 kcal/g. The thick gruels usually prepared for older children contain about 0.8 kcal/g. ("Ugali" has 1 kcal/g.) Cooked bananas and potatoes have slightly lower energy densities. Other foodstuffs, such as beans, vegetables, meat, and fish, are added in very small amounts, usually after the age of 18 months. From a comparison of different gruel preparations, we see that the use of an ungerminated cereal flour produces a gruel whose energy density is around 0.3-0.5 kcal/g. If cooking oil, cowpeas, or groundnuts are added at a ratio of 4:1, the energy density increases slightly to around 0.5 kcal/g. If groundnuts are added at a ratio of 2:1, the energy density rises to 0.8 kcal/g. When P.F. is used, however, the energy density can reach 1 kcal/g or even higher - 1.15 kcal/g, if groundnuts are added to the P.F. (Svanberg 1985).

Mean Food, Energy, and Protein Intakes

As indicated in the methodology, the study began with 31 children. During the course of the study, nine children dropped out, leaving 22 children who continued to the end of the study; only these 22 children have been included in the analysis. The children were divided into three age groups: 9-24, 25-36, and 37-60 months. Their mean diet, kilocalories, and protein intakes are presented in Tables 2-4.

For children up to 3 years of age, food intake with diet A was significantly higher than that achieved with diets B, C, and D ($p \le 0.01$); for children 3 years of age, food intake was significantly

Table 2. Mean food intake[a] (g) per meal with gruels of different dietary bulk properties.

	Diet			
Age of children (months)[b]	A (n=10) (DM[c]=14%)	B (n=10) (DM=33%)	C (n=7) (DM=27%)	D (n=3) (DM=17%)
9-24 (n=9)a	161 ± 78a	105 ± 76b	138 ± 102b	145 ± 112b
25-36 (n=7)b	482 ± 46a	281 ± 64b	309 ± 49bc	377 ± 84c
37-56 (n=6)b	501 ± 170a	344 ± 114b	370 ± 59ab	472 ± 120ab

[a] Mean values within the same age group followed by the same letter are not significantly different ($p \le 0.01$).

[b] Age groups followed by the same letter are not significantly different ($p \le 0.01$).

[c] DM, dry matter content.

Table 3. Mean energy (kcal) intake[a] per meal with gruels of different dietary bulk properties.

	Diet			
Age of children (months)[b]	A (n=10) (DM[c]=14%)	B (n=10) (DM=33%)	C (n=7) (DM=27%)	D (n=3) (DM=17%)
9-24 (n=9)a	81 ± 39a	124 ± 90ab	133 ± 98b	88 ± 68a
25-36 (n=7)b	242 ± 23a	332 ± 76b	298 ± 47b	228 ± 51a
37-56 (n=6)b	251 ± 85a	407 ± 135c	357 ± 57abc	285 ± 73ab

[a] Mean values within the same age group followed by the same letter are not significantly different ($p \le 0.01$).

[b] Age groups followed by the same letter are not significantly different ($p \le 0.01$).

[c] DM, dry matter content.

Table 4. Mean protein (g) intake[a] per meal with gruels of different dietary bulk properties.

Age of children (months)[b]	**Diet** **A (n=10) (DM[c]=14%)**	 **B (n=10) (DM=33%)**	 **C (n=7) (DM=27%)**	 **D (n=3) (DM=17%)**
9-24 (n=9)a	2.1a	3.3ab	3.4b	2.2a
25-36 (n=7)b	6.3a	8.7b	7.7b	5.6a
37-56 (n=6)b	6.5a	10.7b	9.2a	7.1a

[a] Mean values within the same age group followed by the same letter are not significantly different ($p \leq 0.01$).

[b] age groups followed by the same letter are not significantly different ($p \leq 0.01$).

higher with diet B only ($p \leq 0.05$). Children below 2 years of age consumed significantly smaller amounts of all the diets than did their older counterparts ($p \leq 0.01$). All children gained significantly more nutrients from diets B and C than from diets A and D ($p \leq 0.01$).

Previous intake studies conducted in Tanzania showed that small children normally were able to eat between 300 and 400 g of gruel per meal, and that older children (4-5 years) could eat more than 500 g. For solid foods such as "ugali," the figures were 150-200 g and 300-400 g, respectively (Mosha 1984). In this study, the intake of the younger age group (under 2 years) was much less, both for thin and for thick diets, than had been observed in the previous study (Table 2). This difference could be attributed to the fact that in the previous study, the upper limit of the young age group was 3 years. Observations concerning the older children were, however, similar to those found in this study (Table 2).

The higher intake among all age groups with diet A is due to the diet's thin consistency: children are able to eat thin foods more easily than thick or stiff foods. The amount that children can eat per meal is influenced by their ability to chew and by the capacity of their stomachs. The amount of food eaten also depends on the time and patience of the person feeding the child, on the amount of food available to the household, and on any possible state of anorexia in the child.

In this study, the younger age group (children under 2 years of age) ate significantly less with all the diets than did their older counterparts ($p \leq 0.01$). This is largely attributable to limited stomach capacity. The patience of the person feeding the child is, however, an important factor: young children need to be persuaded to eat more; the younger the child, the greater the effort needed. With diets B, C, and D, however, palatability and consistency could have been the determining factors. It is also likely that diet B was too stiff for all the children. Although it had been anticipated that the intake with diet C would be in the same category as that with diet A, this study proved otherwise: diet C thickened much more upon reboiling and cooling than had been expected. If children were able to consume food at high temperatures (near boiling point), intake with diet C probably would have been the highest of all: at those high temperatures, it was more liquid than any other diet. In other studies, the P.F.-treated gruel was given immediately after thinning (without reboiling), and therefore remained in a fairly liquid state. Although decrease in food intake appears to be due to the physical ramifications of increased consistency, we must take into consideration the tendency of an individual to feel satisfied more quickly when consuming concentrated food than when consuming food that has been diluted.

The results of this study become more meaningful when consideration is given to the amounts of energy and protein provided per meal by the different diets (Tables 3 and 4). From these tables, we see that because of differing nutrient densities, diets B and C supplied significantly more nutrients than did diets A and D ($p \leq 0.01$).

In Tanzania, about 60% of total energy and protein intake comes from the staple food - in this case, cereals (Tanzania Bureau of Statistics Internal Report 1978). Assuming, therefore, that 60% of the children's daily nutrient requirements will come from these diets, the younger children, when consuming diets A or D, will have to eat frequently - up to eight meals in a single day; for diets B and C, the number of meals required per day is almost halved (Table 5). For children over 2 years of age, three or four meals of diets A or D and two or three meals of diets B or C are enough (Table 5). As we have seen earlier, child feeding frequency in the rural areas in Tanzania is two or three times a day.

Conclusions and Recommendations

From this study, we have learned that consistency influences food intake in children under 5 years of age. Thin gruels, usually prepared as weaning foods from ungerminated cereal flours, have very low energy and protein densities. All the children consumed more of diet A than of the other three diets, but gained more nutrients by eating stiff porridge or gruel prepared with P.F.

The number of meals required to meet the RDA is impractically high when children under 2 years of age are served with thin or thick gruels prepared from ungerminated cereal flours; this high frequency of feeding becomes still more difficult in the light of the mothers'

Table 5. Number of meals required per day to meet at least 60% of RDA of energy and protein[a] in each age group.

Age group (months)	Diets			
	A	B	C	D
9-24	8(7)	5 (4)	5 (4)	8 (6)
25-36	3(2)	2 (2)	2.5(2)	3 (3)
37-56	4(3)	2.5(2)	3 (2)	3.6(2.6)

[a] Values in parenthesis are number of meals required per day to meet at least 60% of RDA (protein).

heavy work load. Also a factor is the monotony that may accompany frequent repetition of a diet. Were stiff porridge, or gruel prepared with P.F., to be used, the frequency of feeding could be reduced by almost half and still meet the 60% RDA.

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HIGH-ENERGY, LOW-BULK WEANING FOOD DEVELOPMENT IN ZAMBIA

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Abstract *This paper presents a rationale for weaning-food development, giving background information on sprouting of cereal grains such as millet, sorghum, and maize. This practice of sprouting is shown to be a traditional one, not only in Zambia but in other African countries. A case study was undertaken by the National Food and Nutrition Commission (NFNC); this study evaluated germinated and ungerminated staple cereals for dietary bulk, protein digestibility, and iron availability. The results showed that germination could be used to alter the consistency of high-viscosity gruels, while increasing their energy and other nutrient density. A nutritional study has therefore been proposed on the acceptability and use of germinated cereal flour in weaning foods and on the problems of low food intake among preschool children; this study is to take place in Solwezi District, in the Northwestern Province of Zambia. The project will run for 1 year, after which a seminar will be held to discuss and evaluate the results.*

In Zambia, mortality among preschool children (4 years of age and under) is very high, caused mainly by protein energy malnutrition (PEM) combined with infection. PEM poses a major health threat to the nation: recent estimates (1986) based on hospital records indicate that malnutrition is either a direct cause of, or a major contributing factor in, 70% of child deaths in Zambia. Inadequate food intake has been found to be largely responsible for the prevalence of PEM (FAO/NFNC 1974). With the initiation of weaning, a child enters a very delicate stage of its life. The traditional foods usually introduced to a child during weaning have bulk properties that limit energy and other nutrient intake. A possible solution to this bulk problem has, in recent years, been seen to lie in concentrated energy sources. Such products are, however, costly and therefore rarely available to low-income families. A more practical solution to the dietary bulk problem lies in the use of traditional methods of fermentation and germination - methods that have been shown to reduce the dietary bulk of cereal-based weaning foods.

UNICEF (1986) reveals that in 1980, 6.4% of admissions of children to hospitals throughout Zambia were attributed to PEM and other nutritional disorders. In 1978, these disorders were responsible for about 13% of deaths in children under 5 years of age, as compared with 18% in 1980. This deteriorating situation is the result of a complexity of factors, the major one being the lack of cheap, high-energy, low-bulk local weaning foods. Such foods, if available, could assist mothers in providing an adequate diet during the weaning period.

Breastfeeding in Zambia continues until the child is 2-3 years of age (Dirorimwe 1980). To meet the child's increasing nutrient requirements, however, foods supplementary to breast milk must be introduced when the child is 4 months of age. It is at this stage that food problems emerge, of which dietary bulk is one of the most important.

Dietary bulk may be the limiting factor in energy and nutrient intake in early childhood: it is a problem both of low energy and nutrient density (amount per volume of food) and of consistency.

In rural communities, the most common staple food is maize, followed by cassava, sorghum, and millet. The cereal is made into a flour that is usually prepared as a stiff porridge ("nshima"). The amount of flour in such a porridge is about 30%; this gives an energy density of 1 kcal/g. Although "nshima" is consumed mainly by adults, children, when they reach the age of about 1 year, are introduced to this food. Although the energy density of "nshima" is acceptable, its sticky consistency limits the quantity that can be consumed by children.

To overcome this bulkiness, mothers often dilute the porridge or prepare it with less flour; in both cases, a thin, soft porridge is attained that has a consistency suitable for child feeding (a thin porridge, containing 5% dry matter and giving 0.2 kcal/g, and a softer, thicker porridge with a semiliquid character, containing about 10% dry matter). Food-intake studies have shown that whereas weaning-age children can eat only about 150-200 g of the thick "nshima," they are able to eat 300-400 g per meal of the thin, semifluid porridge. The nutrient density per volume of food in the thin porridge is, however, reduced; to meet his or her nutrient requirements, a child would have to consume about 3-5 L over one or two meals, and that is clearly impossible. The only alternative would be to feed the child at least 6-7 times per day; only in this way would energy and other nutrient requirements be met, especially during illness (Mosha and Svanberg 1983). The heavy work load of women, particularly during the farming season, makes this frequency of feeding impracticable.

Rationale

The energy and nutrient density of weaning foods can be increased by the addition of oil, fats, or sugar (Wilfart 1983). These concentrated energy sources increase the energy density and reduce viscosity; they are, however, too expensive for the poor. An alternative solution to the dietary bulk problem is the increased use of improved traditional food preparation methods, such as fermentation and germination.

Fermentation of cereals breaks the starch structure and reduces the water-binding capacity of the porridge. The fermented products are usually used for alcoholic beverages. Studies conducted in Zambia on fermented products have thus far been limited; further studies are needed, firstly to develop products of adequate energy density, and subsequently to test these products for their acceptability.

Germination, on the other hand, is a traditional process that is used in the brewing of local beer. In germinating seeds, amylolytic enzymes are developed in cereal varieties. The alpha-amylases are synthesized within the cells of the aleurone layer; from here, they migrate to the starchy endosperm, where hydrolysis of the starch granules begins (Mosha 1984; Svanberg 1985). This means that upon cooking, the starch granules will not swell to the same extent, and the amylase chains (which form the gel network) will be broken down. Studies carried out by Mosha and Svanberg (1983) also show that when a small amount of germinated flour is added to thick porridge, the porridge is liquefied within minutes.

Practice of Germination

The practice of sprouting seeds of various cereal grains (such as millet, sorghum, and maize) is an old tradition in Zambia (Richards 1939; Thompson 1954). The practice of sprouting has also been reported in South Africa, Botswana, and Swaziland (Novellie 1977), and in Tanzania (Mosha and Svanberg 1983). In all these reports, germination of cereals was used in the brewing of beer: this involves a twofold process of fermentation - with bacteria that produce lactic acid, and with yeasts that produce alcohol. In Zambia, sprouted cereal flour is also used to prepare, on a small scale, a nonalcoholic sweet beer called "munkoyo." This beverage is based on the roots of Rhynchosia insignis. Research is underway to enable its production on a commercial scale.

For germination, seeds are soaked in water and sprouted for 1-4 days, depending on the product one wishes to make. Banana leaves are traditionally used to sprout the seeds. After sprouting, the seeds are dried on mats and milled to obtain flour. During this process, there are many changes that occur in chemical composition (Lorenz 1980), including changes in dry matter and in total protein. Of particular importance to the study under consideration were the antinutritional factors associated with germinated foods: these include aflatoxins, cyanide development, tannins, phytates, and fecal coliforms.

Research has revealed that during germination, mycotoxins such as aflatoxins produced from Aspergillus flavus, Pasticus, and Penicillium moulds are developed (Frazier and Westhoff 1978). After the germinated seeds have been washed, cooked, or dried at high temperatures, however, these mycotoxins are destroyed. It is also reported that germinated sorghum seeds contain detectable amounts of dhurrin - a cyanogenic gycoside that yields hydrocyanic acid upon hydrolysis (Akazawa et al. 1960). This cyanide exists in the form of heat-stable, nonvolatile cyanogenic glycoside; it cannot be destroyed, either by drying or by cooking. The amount intended for use in the porridge to reduce dietary bulk is, however, very small (5-10 g/100-125 mL). This constitutes 18.6-37.23 ppm/100-250 mL of hydrocyanic acid, which is less than the average permissible consumption level of 200 ppm/day of hydrocyanic acid (Conn 1973). Nevertheless, to ensure safety in the use of sorghum sprouts, studies are required to measure the hydrocyanic acid levels in porridge prepared in the household.

Tannins and phytates are naturally occurring substances in sorghum and millet. Tannins are reported to inhibit protein digestibility; phytates have been shown to bind minerals such as iron and zinc. One advantage of the germination procedure is that it considerably reduces the levels of tannins and phytates (Mosha and Svanberg 1983).

Untreated water used in the rural areas for soaking seeds has been shown to be contaminated with fecal coliforms that are likely to cause diarrhea (Svanberg 1985). This water should be reboiled to get rid of the coliforms and other bacteria.

Case Study

A laboratory-based case study was undertaken by the NFNC; this study evaluated germinated and ungerminated staple cereals for dietary bulk, protein digestibility, and iron availability (Luhila 1986). The study had two aims: the first was to determine whether the use of germinated cereal flour in sorghum- and millet-based porridge reduces dietary bulk; the second was to determine whether protein digestibility and iron availability can be improved through germination.

Methodology

The seeds of sorghum and millet were first washed in 0.2 hydrochloric acid. Half the seeds were soaked for 16 h and germinated for 48 h; they were then dried and milled. Both germinated and ungerminated samples were analyzed for nitrogen content, using the method described by Hambraeus et al. (1976). Crude protein levels were obtained by multiplication by the factor 6.25. In vitro protein digestibility was analyzed by the method described by Mertz et al. (1984). Total iron was determined by atomic absorption spectrophotometry after wet-washing in nitric acid. In vitro iron availability was analyzed by the method described by Narasinga and Prabharathi (1978). The viscosity of sorghum (Zambia Sorghum Variety 1 (ZSV1)) was measured using a Haske Rotovisco model RU1, with an SC 11 profile measuring system and a shear rate of 54 rounds per minute.

Results and Discussion

Total nitrogen increased in germinated sorghum varieties (local and ZSV1) and in germinated millet (local variety). Total iron also increased in germinated sorghum and in germinated millet (local varieties). These increases are attributable to dry-matter losses through respiration. In vitro protein digestibility increased in germinated sorghum (ZSV1) and decreased in germinated millet (local variety). The increase, according to Mosha and Svanberg (1983), could have been due to a decrease in tannin content. In vitro iron availability increased in germinated millet but not in sorghum (ZSV1). Here again, the increase could have been the result of a decrease of inhibitors such as phytates.

The viscosity measurements of ungerminated and germinated sorghum at a consistency of 3000 cP (the suitable eating consistency for children) indicated that the concentration of ungerminated flour was 13%. In order that a similar consistency be attained before the viscosity became high and unsuitable for child feeding, a double amount of germinated flour was required. Moreover, when 10% germinated cereal flour was added to thick porridges prepared from ungerminated flour, the dietary bulk was reduced.

Conclusions

The study showed that germination - a traditional method known not only in Zambia but in the SADCC region as well (Vogel and Graham 1979) - could be used to reduce the consistency of high-viscosity gruels, and at the same time increase energy and other nutrient density. As a result, further research on the acceptance and use of germinated cereal flour is underway.

Future Research

A project has recently been undertaken by NFNC to investigate the following: weaning food practices, nutritional status of preschool children, frequency of feeding, beer-brewing practices, and the provision of sanitary services, of water supply, and of food.

In light of the potential of germinated cereals for use in weaning foods, and because of the problem of PEM among preschool children, we shall test the hypothesis that "the use of germinated cereal flour in weaning foods would lead to improved food intake in children and, consequently, improve the nutritional status of the children." Other variables in the study will include: acceptance and adoption of the use of germinated cereal flour in weaning foods, existing methods of germination, storage of malted flour, and general handling of malted flour. If sprouted sorghum or millet is used, the hydrocyanic acid will be measured in the dietary bulk-reduced porridge. The long-term objective of this project is to determine the impact of the intake of bulk-reduced porridge on the nutritional status of preschool children.

Methodology

The northwestern province has been chosen as the first for implementation of the project. This province is one of the few in which nutrition surveys have recently been conducted; these studies found malnutrition to be prevalent. A second reason for this choice of province is the fact that its institutional infrastructure for training and for nutritional work is comparatively well developed: there is a "Nutrition Mobile Team Program" in the northwestern province, covering the three districts of Solwezi, Kasempa, and Mwinilunga; it is sponsored by the Area Development Project.

Because their funds are limited, however, the NFNC project will be confined to the Solwezi District. Using the same sample points as those used by the Nutrition Mobile Team Program, all the children between the ages of 3 and 36 months will undergo preliminary assessment for malnutrition. Data on frequency of feeding, weaning practices, health status, sanitation, brewing practices, and food availability will be collected. Using stratified, random sampling, a total of 300 households will be selected from the Solwezi nutritional status survey for the study. The anthropometric study will include growth and physical development in relation to height and weight. The nutritional indicators that will be used to screen for chronic and present malnutrition are weight/age and weight/height. All other factors to be included in this study will be reflected in a questionnaire. After the preliminary assessment study, the households selected will be categorized according to the experiments that will be carried out in each area; the children will be grouped for feeding as follows:

- Group 1 - Children will be fed porridge made with germinated cereal flour that has been supplemented with groundnuts or beans;
- Group 2 - Children will be fed porridge made with ungerminated cereal flour that has been supplemented with groundnuts or beans; and
- Group 3 - Children will be fed porridge made with unsupplemented, ungerminated cereal flour.

Group 1 will receive bulk-reduced porridge as well as supplementation with other nutrients; group 2, although supplemented, will retain the problem of bulk; and group 3 will act as a control. Respondents (mothers) in groups 1 and 2 will be taught how to prepare groundnuts or beans for use as a supplement in weaning foods. Those in group 1 will also be taught how to select cereal seeds, germinate them in hygienic conditions for 2 days, and store them properly.

The study will test the willingness of the mothers to use germinated cereal flour, supplemented with groundnuts or beans, in weaning foods. In this experiment, demonstrations will be made of the effects of germinated cereal flour. The mothers will be asked to observe the consistency of plain porridge and that of porridge made with germinated flour and a supplement. The porridges will then be served to the mothers, and their reactions recorded on a hedonic scale as shown by Mosha (1984). Parameters used in this study will include smell, colour, taste, texture, and general willingness on the part of the mothers to use the product. In addition, the preparation of protein-supplemented porridge will be demonstrated and organoleptically tested by respondents in group 2.

The study will then test the willingness of the children to eat supplemented, bulk-reduced porridge and supplemented, untreated porridge. To determine the amount of porridge the children are able to consume, actual intake will be measured. These acceptability studies will be carried out for 2 months, for 5 days in each month. This period will allow the mothers experience in weighing or estimating food amounts, in preparation, and in feeding; they will then be ready to adopt the experimental germinated cereal supplements at the household level. Records of frequencies of feeding will also be kept.

Progress reports and monitoring data will be provided at the household, local, and district levels on a quarterly basis. Parents will be trained on the use of growth chart information; they will therefore be able to determine whether their child is underweight, and to seek advice from the health workers. The annual review will provide an effective tool with which to assess the implementation and impact of the project. A seminar will also be held, in which the results of the research will be explained to the participants.

The participants will include nutritionists, health workers, community workers, and agricultural extension staff. Relevant organizations such as the University of Zambia and UNICEF will be invited. NFNC will cooperate with other groups in carrying out the project; these groups will include the district council, ward officials, social development officials, hospitals, clinics, the nutrition group, and women's clubs.

Conclusions

Porridges made with sorghum, millet, and maize are widely used as weaning foods in Zambia. Such porridges are not only low in energy but also bulky, making it difficult for small children to consume enough to meet their needs. Although bulk reduction can be achieved by the addition of sugar, oil, and fat to the porridge, these items are too expensive for the poor. A possible solution to the dietary bulk problem is the use of traditional methods of fermentation that have been shown to reduce the dietary bulk of cereal-based weaning foods.

The rationale for weaning food development has been given. It has also been shown that germination of cereals is a traditional practice. Although germinated cereals have been used mainly for brewing beer, the practice of germination can now be used for reducing dietary bulk and, at the same time, increasing the density of energy and of other nutrients. The project on the use of germinated cereal flour will take place in the Solwezi district of the northwestern province of Zambia. This project will run for 1 year; at the end of this year, a seminar will be held to discuss and evaluate the results.

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BULK REDUCTION OF TRADITIONAL INDIAN WEANING GRUELS

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Abstract *Amylase-rich foods (ARFs) were prepared from pearl millet (Pennisetum typhoideum), from maize, and from sorghum. Sun drying of these grains yielded ARFs of maximum amylase activity (1248 and 1855 maltose units for maize and sorghum, respectively). Roasting in a traditional iron pan lowered the amylase activity drastically. It was found, however, that roasted ARFs had a prolonged shelf life of 21 days, whereas sun-dried ARFs had a shelf life of only 7 days. Also discussed is the effect of different solids concentrations on the viscosity of the gruels. Acceptability trials were conducted to compare the mean intakes of gruels with and without ARF, by infants and by toddlers. Because the method of ARF preparation is traditional, simple, and inexpensive, it can be transferred to house-holds at the village or community level.*

In India, the first or early introductory foods for infants and toddlers are gruels made from staple flours such as rice, wheat (Triticum aestivum), bajra (Pennisetum typhoideum), maize (Zea mays), and sorghum (Sorghum vulgare) (Jelliffe 1968; ICMR 1977). The starch granules in these staple flours swell on cooking; this in turn contributes to the bulkiness or dietary bulk of these gruels, giving a low caloric density per unit volume of food consumed. Older infants (over 6 months of age) or young toddlers (13-36 months) cannot ingest sufficient amounts of such preparations to fulfill their daily energy requirements (Nicol 1971; Rutishauser 1975; Hellstrom et al. 1981; Cameron and Hofvander 1983). It is vital, therefore, that simple means be established whereby the caloric density of traditional weaning foods may be enhanced.

For the last 7 years, the Department of Foods and Nutrition of Maharaja Sayajirao (M.S.) University, Baroda, Gujarat, India, has been working extensively with fully malted multimixes made from combinations of cereals such as wheat, rice, or ragi (Eleusine coracana), of pulses such as bengal gram (Cicer arietinum) or green gram (Phaseolus aureus), and of oilseeds such as groundnut (Arachis hypogaea). When compared with their roasted counterparts, the hot paste slurries of these malted multimixes were found to have much lower viscosity or dietary bulk, higher levels of acceptability with mothers and children, and significantly higher intake levels per sitting among older infants or those used by the Nutrition Mobile Team Program, all the children toddlers. The overriding constraints with regard to the use of these malted multimixes were, however, the time, labour, and space required for their production. These factors proved to constitute a strong barrier to the transfer of the technology to the community or household (Tajuddin 1980; Gopaldas et al. 1982; Gopaldas 1984).

Malleshi and Desikachar (1982) reported that because of its high amylase content, a 5% addition of malted barley flour substantially reduced the viscosity of a 15% hot paste slurry of branded Indian weaning foods such as Nestum, Farex, Cerelac, and Balamul. In 1983, the Tanzania Food and Nutrition Centre (TFNC) reported that small quantities of germinated sorghum flour, or "power flour" (P.F.), when added to traditional African gruels made from sorghum flour, could effectively thin these viscous gruels (Mosha and Svanberg 1983).

Despite the value of the preliminary observations of Malleshi and Desikachar (1982), and of the work of the TFNC group, further research needs to be undertaken on the production and shelf life of amylase-rich food (ARF), and on the acceptability and intake, in rural and slum settings, of traditional gruels with and without ARF.

In our department, the concept of ARF has been studied in depth with respect to the foregoing parameters. In this paper, we bring together relevant data from three dissertations on the reduction of the dietary bulk in gruels made from rice (Gopaldas et al. 1986), from maize (Kapoor 1986), and from jowar (Chaudhary 1986); this reduction was effected by the addition of bajra, maize, and jowar ARFs, respectively.

Preparation of Bajra, Maize, and Jowar ARFs

As can be seen from Table 1, the optimum conditions for the development of the three ARFs were found to differ. Through a process of trial and error, we now know that steeping the grains for more than 12 h (or overnight) results in the leaching of starch. In our earlier attempts with bajra ARF, we considered "kadai" (the traditional iron frying pan) roasting and the production of a malt to be important. This was found, however, to result in greatly reduced amylase activity in the ARF (Table 2). Oven drying at 50°C conserves the amylase activity; such a procedure is not, however, feasible in village homes. In our latest studies, sun drying, in which ambient temperatures of 40 ± 2°C are attained, appears to be the most suitable technology to be transferred to village homes. Sun-dried samples have high levels of amylase activity (Table 2). In India, germination of grains is universally known and practiced, as is the sun drying of vegetables, fruit slices, etc., to prolong their shelf life. The methodologies proposed for ARF preparation - steeping, germination, and drying - are easily within the competence and understanding of any modest Indian home.

We wish to stress here the importance of the removal of all vegetative parts (rootlets and shoots) from the germinated sorghum grains before milling. Recent studies on the sprouting of sorghum have reported a marked increase in the hydrocyanic acid content of sprouts. The average amount of hydrocyanic acid (61.3 mg) obtained

Table 1. Optimum conditions for production of bajra, maize, and jowar ARFs.

Stages of production	Bajra ARF	Maize ARF	Jowar ARF
Steeping	2 h in equal volume of water	12 h in double the volume of water	12 h in double the volume of water
Germination	72 h in wet muslin cloth	96 h in wet muslin cloth	72 h in wet muslin cloth
Air drying	Until dry to touch, about 12 h	-[a]	-
Sun drying	-	Until dry to touch, about 8 h at 40 ± 2°C	Until dry to touch, about 8 h at 40 ± 2°C
Oven drying	-	Until dry to touch, about 5 h at 50°C and subsequent removal of vegetative portion	Until dry to touch, about 5 h at 50°C and subsequent removal of vegetative portion
Roasting	15 min till brown colour and malt aroma developed	-	-
Milling	To fine powder in commercial mill	To fine powder in electric mill	To fine powder in electric mill
Storage	150 g of ARF in 200 gauge polythene bags, heat sealed and kept in airtight glass jars	150 g of ARF in 200 gauge polythene bags, heat sealed and kept in airtight glass jars	150 g of ARF in 200 gauge polythene bags, heat sealed and kept in airtight glass jars

[a] -, steps not carried out in the production of that particular ARF.

from the sprouts of 100 g of seeds (dry-weight basis) exceeds the fatal dose for an adult (Panasiuk and Bills 1984). We therefore took the precaution of removing the vegetative parts from the sorghum seeds before milling by hand abrasion. The TFNC group has been including the vegetative parts of germinated sorghum in the P.F.; in the matter of child feeding, this is of paramount importance. As with any other cereal grains, the desprouted grains can be sent to a local miller for grinding. In the case of small batches of grains, a household stone mill (one flat circular stone atop another), a metal mortar and pestle, or a flat grinding stone can be used; these are tools that are available and very frequently used in almost every Indian home.

A batch of 500 g of ARF can be kept for 1-3 weeks, under conditions of ambient temperature and relative humidity (Table 3).

Table 2. Amylolytic activity (mg maltose/g ARF) of pearl bajra, maize, and jowar ARFs.

	Roasting	Oven drying (5 h, 50°C)	Sun drying (8 h, 40 ± 2°C)
Bajra ARF	99.9	–[a]	–
Maize ARF	–	1263	1248
Jowar ARF	–	1608	1855

[a] –, steps not carried out.

Table 3. Shelf life of bajra, maize, and jowar ARFs.

		Bajra ARF (R)[a]		Maize ARF (S)		Jowar ARF (S)	
Specification	**IS/PFA specification**	**0 day**	**21st day**	**0 day**	**21st day**	**0 day**	**21st day**
Moisture content	10%	3.47	8.10	10.77	11.95	5.86	7.63
Alcoholic acidity	0.12% (as H_2SO_4)	0.026	0.042	0.036	0.0357	0.030	0.069
Peroxide value	10 mg/g	0.95	6.27	nil	nil	nil	nil
Free sugar	No specification	10.31	4.78	13.14	12.12	8.80	8.41
Bacteriological count	50000/g of ARF	29166	46500	–[b]	–	–	–

[a] R, roasted for 15 min; S, sun dried for 8 h at 40 ± 2°C.
[b] –, not carried out for that particular ARF.

During this period, there will be sufficient food for a small amount of ARF to be used daily for the thinning of gruels for two children under 3 years of age. Furthermore, a batch of 500 g of pearl millet bajra ARF, maize ARF, and sorghum ARF would cost the mother only about INR 1.15, 1.50, and 1.15, respectively (as of 1987, 13 Indian rupees [INR] = 1 United States dollar [USD]).

Shelf Life Studies

Using standard procedures (Gopaldas 1984), the shelf life of the ARFs was assessed in terms of moisture content, alcoholic acidity, peroxide value, free sugar, and bacteriological count. The ARF samples were stored in heat-sealed, 200-gauge polythene bags and were drawn on days 0, 7, 14, 21, and 28 for analysis. Table 3 gives information on values obtained on 0 day and on the last acceptable day, and shows the IS and PFA specifications for these parameters.

The data indicate that two important factors determine the shelf life of an ARF: these factors are, firstly, the fat content of the cereal used, and second, the moisture content of the ARF. The ARF from maize (with a fat content of 6%) had a poor shelf life, as indicated by its high alcoholic acidity - a measure of the degree of deterioration in the fats. Moisture is necessary for survival and multiplication of microorganisms; because of the roasting treatment applied, the ARF from bajra (a low-fat grain) had a low-moisture content and therefore a good shelf life. Currently under investigation is the possibility that the shelf life of ARF from low-fat grains can be extended by toasting sun-dried grains on a flat griddle over charcoal embers (low heat) until the grains are brittle.

Amylolytic Activity of the ARFs

Processing conditions, especially temperature, are important in determining the amylolytic activity of ARF. Amylase activity (Bernfield 1955) in ARF varies according to whether preparation is by roasting, oven drying (50°C), or sun drying (40 ± 2°C) (Table 2). The reduction in amylase activity is marked with an increase in processing temperature. Malleshi and Desikachar (1986) reported amylase activity of 150 and 170 mg maltose/g of malt for maize and jowar, respectively, germinated for 96 h and kilned at 70°C. Because our main aim was to use ARF as catalytic agents to lower the viscosity of gruels, it was desirable to obtain an ARF with maximum catalytic activity; this was achieved by sun drying, a simple and familiar procedure, followed by toasting on a flat griddle over charcoal embers; this produced an ARF with a shelf life of 2-3 weeks, and also conserved amylase activity.

Viscosity Reduction of Gruels

Gruels with a viscosity of 50,000 cP or more are dough-like; those between 10,000 and 40,000 are very thick and nonspoonable; those between 6000 and 10,000 are thick and spoonable, with drop-batter consistency; those between 3000 and 6000 are easily spoonable and of pour-batter consistency; those between 1000 and 3000 have a thick, soup-like consistency; and those less than 1000 are free-flowing liquids. The gruels were prepared as shown in Table 4. Bajra ARF was added to rice gruel (as rice cannot be germinated to prepare ARF), maize ARF to maize gruel, and jowar ARF to jowar gruel. Although a striking reduction in viscosity was obtained in the gruels to which ARF was added, the caloric content of the gruels (10% rice gruel, 15% maize gruel, 10% jowar gruel) was very low. Increasing the solids concentration to 25% increased the caloric content by 1.5 times in the case of maize gruel, and 2.5 times in the case of rice and jowar gruels. At levels of even 16% or above of solids concentration, it was not possible to reduce the viscosity of 25% rice gruel below 6800 cP with the addition of ARF; the gruel was, however, spoonable. Twenty-five percent maize and sorghum gruels with 10 and 8% ARF, respectively, had thick, soup-like consistency. Several investigators (Malleshi and Desikachar 1982; Mosha and Svanberg 1983) have reported that gruels with viscosities of 1000-3000 cP are appropriate for child feeding. Our current studies have shown that mothers prefer to feed their children with thick, spoonable gruels (2000-6000 cP) rather than with thin, free-flowing gruels (1000 cP). If, therefore, the solids concentration and the level of ARF are increased to obtain a gruel of the desired consistency, the caloric densities of these gruels will be increased proportionately.

Table 4. Optimum levels of ARF and Takadiastase required for effective thinning of gruels.

Amount of flour (g)/200 mL gruel	Water (mL)/ 200 mL gruel	ARF^a or Takadiastase^b (g)	Viscosity (cP)	kcal/200 mL gruel
Rice gruel 10%				
20.0	180	-	2780	-
19.0	180	0.8^a	312	69
19.2	180	0.4^b	325	-
Rice gruel 25%				
50.0	150	-	37200	172
42.0	150	8.0^a	6800	-
Maize gruel 15%				
30.0	170	-	3750	-
28.5	170	1.5^a	440	103
28.5	170	1.5^b	1100	-
Maize gruel 25%				
50.0	150	-	30000	171
45.0	150	5.0^a	1800	-
Jowar gruel 10%				
20.0	180	-	3100	-
19.4	180	0.6^a	300	70
19.4	180	0.6^b	1200	-
Jowar gruel 25%				
50.0	150	-	12000	175
46.0	150	4.0^a	1800	-

Note: Brookfield Viscometer LVT Model No. 50 was used for viscosity measurements.

For the intake trials, porridges were prepared using cereal flour. Jaggery (unrefined brown sugar) was added at the level of 40% of the weight of flour for rice and jowar gruel, and for maize gruel at 60% level. Oil was incorporated at the 20% level. The additional effect was studied of jaggery and oil on viscosity reduction; the results are presented in Table 5. The data show that the predominant reduction in viscosity was caused by the ARF alone. Although the decrease in viscosity with the addition of jaggery and oil was not remarkable, there was a significant increase - by 200% - in caloric content. We see, therefore, that the incorporation of jaggery and oil at optimum levels not only improves the palatability of the gruels, but also markedly increases their caloric density.

Intake Studies

Gruels were prepared from rice, maize, and jowar, with and without ARF (Tables 6 and 7). Children were carefully pair-matched for age and randomly assigned either to the control or to the experimental group. The intake trials were conducted from 11:30 A.M. to noon each day, for 7 days; this generally ensured a gap of 1-1.5 h from the last home-diet feed. A serving of 100 mL of gruel (control gruel without ARF, or experimental gruel with ARF) was then offered to the subject, who was fed by his or her mother. The investigators prepared the gruel in bulk every day of the trial, at the site of feeding. Feeding time for gruel consumption was limited to 30 min. If the child finished the first serving, he was offered another 100 mL of gruel. Plate waste was measured, and the net intake/child per sitting recorded. Although the infants (6-12 months) and toddlers (13-36 months) consumed significantly higher amounts of porridge with ARF, the caloric intake was poor. Mosha and Svanberg (1983) have calculated that a child should consume 1200 mL of sorghum gruel with germinated sorghum flour (16.15 g ungerminated sorghum flour + 0.85 g germinated flour/100 mL of gruel) to meet 60% of his or her daily energy requirements (total caloric requirements = 1180 kcal). Two points have, however, arisen consistently in our intake trials: firstly, the mean gruel intake per sitting did not exceed 100 mL for infants and 150 mL for toddlers; secondly, because most of the mothers

Table 5. Reduction in viscosity of gruels on addition of jaggery and oil.

Amount of flour (g/200 mL gruel)	ARF (g)	Water (mL)	Jaggery[a] or oil[b] (g)	Viscosity (cP)	kcal/ 200 mL gruel
15% maize gruel					
30.0	-	170	-	3750	103
28.5	1.5	170	-	440	103
28.5	1.5	170	18[a]	160	172
28.5	1.5	170	18[a] + 6[b]	140	226
10% jowar gruel					
20.0	-	180	-	3100	70
19.4	0.6	180	-	300	70
19.4	0.6	180	8[a]	60	101
19.4	0.6	180	8[a] + 4[b]		137

Table 6. Composition of 100 mL rice, maize, and jowar gruel.

Flour (g)	ARF (g)	Jaggery (g)	Oil (g)	Water (mL)
Rice gruel, control (10.0)	-	4	2	90
Rice gruel, experimental (9.6)	0.4[a]	4	2	90
Maize gruel, control (15.0)	-	9	3	85
Maize gruel, experimental (14.25)	0.75[b]	9	3	85
Jowar gruel, control (10.0)	-	4	2	90
Jowar gruel, experimental (9.7)	0.3[c]	4	2	90

[a] Bajra ARF.
[b] Maize ARF.
[c] Jowar ARF.

Table 7. Mean intake of gruels with and without ARF by infants (6-12 months) and toddlers (13-36 months).

Type of porridge	Mean gruel intake (mL)		Mean calorie intake (kcal)	
	Infants (n=15)	Toddlers (n=15)	Infants	Toddlers
10% rice gruel, control	55.70 ± 0.96	-[a]	38	-
10% rice gruel, experimental	107.60 ± 1.10[b]	-	72[b]	-
15% maize gruel, control	42.00 ± 6.40	86.00 ± 6.50	50	97
15% maize gruel, experimental	102.00 ± 10.50[b]	156.00 ± 10.04[b]	113[b]	170[b]
10% jowar gruel, control	65.61 ± 8.45	99.28 ± 8.15	46	69
10% jowar gruel, experimental	115.28 ± 9.75[b]	186.32 ± 14.61[b]	78[b]	131[b]

[a] -, steps not carried out.
[b] Highly significant ($p \leq 0.05$).

from low socioeconomic groups in India work away from home and cook only once or twice a day, it would not be feasible to feed the children this gruel more than three times a day. The solution, therefore, would be to increase the caloric density by increasing the percentage solids concentration, and by incorporating jaggery and oil at optimum levels. A 25% gruel with ARF would provide 200 kcal/100 mL, compared with the 80 kcal provided by 10% gruels with ARF. Assuming that 100 mL is consumed twice a day, this gruel could meet a third of the child's total daily caloric requirements (ICMR 1981).

Conclusions

In selecting grains for ARF preparation, those with low fat and high starch content should be chosen. For the preparation of ARF, those methods should be employed that are simple enough for easy adaptation to the household level. Sprouts or the total vegetative parts should be removed before milling. For extended shelf life, the grains should undergo prolonged sun drying, followed by light toasting.

It should be remembered that staples such as rice and sago cannot be germinated. Gruels can, however, be prepared from these staples; ARF from other cereals or millets (such as wheat, bajra, jowar, maize, and ragi) consumed in the particular region can then be added to reduce the viscosity of the gruels. These gruels should be made as calorie-dense as possible by an increasing of the solids concentration parts should be removed before milling. For extended shelf life, the grains should undergo prolonged sun drying, followed by light toasting.

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MALTED WEANING FOODS IN INDIA

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Abstract *This paper discusses the research undertaken to develop weaning food formulations based on malting techniques. The studies required a combination of cereal and legume; finger millet (Eleusine coracana) and mung bean (Phaseolus radiatus) were chosen for the preparation of the malted weaning food (MWF). The studies examined the MWF for the following factors: dietary bulk (paste viscosity); protein efficiency ratio (PER); net protein utilization (NPU); biological value (BV); and true digestibility (TD); comparisons were made with proprietary weaning foods. Child feeding studies conducted at a hospital, a labour crèche (organized child-care centre for children of working mothers), and an orphanage revealed that the food was well accepted and tolerated by the weaned children. It produced adequate growth in the children and maintained the normal composition of their blood. The food had a shelf life of about 150 days when packed in polythene pouches and stored at ambient storage conditions. Several trial batches (100-200 kg) were produced for nutritional and commercial assessment. The process 'know-how' has been released for commercial exploitation. The cost of this food is considerably lower than that of other weaning foods marketed in India.*

The weaning stage is an extremely important one in a child's life: during this period, growth is rapid, and the mother's milk alone will not suffice to meet the child's calorie and nutrient requirements. It is essential, therefore, to introduce semisolid foods as supplements to breast milk.

The weaning foods marketed in India are very expensive, and are therefore beyond the purchasing power of the needy sector of the population. Mothers belonging to the middle and lower income strata often modify the already available adult foods to suit the taste of the children. The adult foods and also the marketed roller-dried foods absorb large quantities of water and become bulky when prepared for feeding. High dietary bulk limits the calorie and nutrient intake per feed (Ljungqvist et al. 1981). Moreover, the stomach capacity of the child is limited, and its ability to digest starchy foods is not fully developed.

There is a need, therefore, to develop weaning foods that are easily digestible, nutritionally balanced, of low dietary bulk, and high in calorie density. It is also important, however, that these be foods that can be sold at a price affordable to low income groups, or even be produced at the household or community levels. Several simple, popular, traditional processes were screened by researchers; they wished to see the effect of these processes on the paste viscosity and nutritional quality of the finished product. The malting of cereal grains was promising; this technique of preparing food for children is a familiar one in many homes (Desikachar 1980; Brandtzaeg et al. 1981). Malting or sprouting not only produces a gruel of low viscosity, but also partially digests the starchy and protein components, reduces antinutritional and flatus-producing factors, improves the availability of minerals, and enhances some of the vitamin content of food materials. Malting also imparts desirable flavour and taste to the product; a detailed program of research was therefore undertaken to develop weaning food formulations based on malting techniques.

Selection of Raw Materials

To achieve, at moderate cost, a nutritional balancing of the quantity and quality of food proteins, it was necessary to find an appropriate combination of cereals and legumes. A wide range of these ingredients were examined for their suitability. Finger millet was chosen for a number of reasons: its malting is already practiced in some regions of India; it is rich in calcium, a mineral needed for child growth; its protein is rich in methionine content (Kurien et al. 1960); its malt has a desirable aroma and taste; the malting of finger millet is simple to do; and, finally, it does not develop mould or deteriorate in flavour during germination (Malleshi and Desikachar 1986a). Among the legumes suitable for the feeding of weaned children, mung bean was a natural choice: it is almost free from enzyme inhibitors, from antigrowth factors, and from flatus-producing constituents, and its protein is rich in lysine (Narayana et al. 1973). Finger millet and mung bean proteins complement each other very well. Because the oilseed meals and other protein-rich foods cannot readily be prepared at home, they were not used in the study.

Preparation of Malts

The millet and the legume were steeped for about 16 h. The finger millet was allowed to germinate for 2 days, and the mung bean for 1 day; they were then dried, either in the sun or in a mechanical drier. Rootlets from the finger millet were separated by gentle brushing, and the green malt was kilned at approximately 65°C for about 30 min in a roaster. The kilned malt was sprayed with 5% water, tempered for about 10 min, powdered, and sieved through a 60-mesh sieve so as to obtain a finger millet malt flour that was almost free from bran (Malleshi and Desikachar 1981). The sprouted mung bean was split, and its seedcoats separated in one operation in a plate mill. The splits were then given a mild toasting, and powdered to prepare mung bean malt flour (Fig. 1). Under these conditions of heat treatment, the losses in alpha-amylase activity and in available lysine were minimal (Malleshi and Desikachar 1986b).

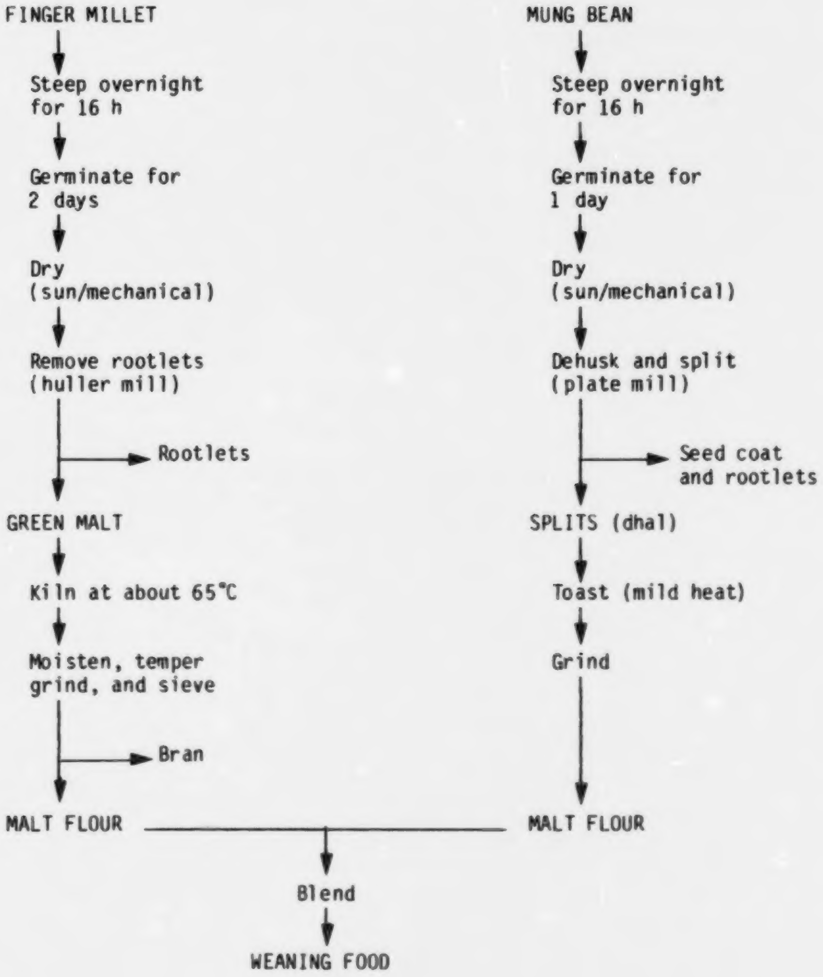
FINGER MILLET
Steep overnight for 16 h
Germinate for 2 days
Dry (sun/mechanical)
Remove rootlets (huller mill)
Rootlets
GREEN MALT
Kiln at about 65°C
Moisten, temper grind, and sieve
Bran
MALT FLOUR
MUNG BEAN
Steep overnight for 16 h
Germinate for 1 day
Dry (sun/mechanical)
Dehusk and split (plate mill)
Seed coat and rootlets
SPLITS (dhal)
Toast (mild heat)
Grind
MALT FLOUR
Blend
WEANING FOOD

Fig. 1. The preparation of malted weaning food.

The millet malt flour was mixed with mung bean malt flour in a proportion of 70:30 to make the weaning food blend. This blend is popularly termed malted weaning food (MWF). The weaning food blend contained about 12.0 g protein, 2.0 g fat, 77.0 g carbohydrates, 2.0 g fibre, 250 mg calcium, and 210 mg phosphorus (Table 1). The composition was comparable to that of popular brands of proprietary weaning foods, and was in accordance with the standards laid down for such foods by the Indian Standards Institution (ISI 1969). The fibre content of the food was within the allowable limits for weaning foods (Jansen 1980). The blend was fortified with the necessary vitamins and minerals and used for child feeding studies.

Table 1. Composition of malted weaning food (MWF) and proprietary weaning foods marketed in India (per 100 g food).

		Proprietary foods[b]			
	MWF[a]	1	2	3	4
Moisture (%)	6.0	3.5	5.0	2.2	4.0
Protein (g)	11.5	12.0	7.5	11.0	22.0
Fat (g)	1.5	3.5	-	7.8	3.5
Carbohydrates (g)	76.7	75.0	84.0	77.0	68.0
Crude fibre (g)	2.0	-	-	-	-
Total ash (g)	2.3	3.5	3.0	2.0	-
Calcium (mg)	250	750	690	275	800
Phosphorus (mg)	210	400	570	225	690
Calories	396	350	366	422	380

[a] Plain mix, not fortified.

[b] Prepared by roller-drying technique, contain cereal, cereal and milk, or cereal, legumes, and milk.

The MFW is not a ready-to-eat food: it requires preparation and cooking before being served. When the food suspended in cold water or milk is heated slowly to boiling, the malt amylases hydrolyze the starch to dextrins and low molecular weight sugars, thereby reducing the water-holding capacity or bulk of the food. Simultaneously, the proteins are also hydrolyzed. Processed in this way, the food slurry not only thins down, but also becomes to a certain extent predigested; the food is thus made easier for the child to digest. The viscosity or dietary bulk of the MWF was very low, as compared with the roller-dried, extrusion cooked, popped, or flaked cereal-based weaning foods at all comparable slurry concentrations. This clearly demonstrates the advantage of the malting technique in preparing low-viscosity weaning foods (Malleshi and Desikachar 1982).

The viscosity or dietary bulk of conventional weaning foods (prepared with precooked materials), or even that of the cereal/legume blend, could be reduced significantly by the addition of a small proportion of cereal malt during the preparation of the slurry (Malleshi, Raghavendra Rao 1986); alternatively, the dry food could be mixed with malt flour and packed for distribution. The addition of malt flour does not affect the sensory acceptability, nutritional quality, or shelf life of the foods (Malleshi and Desikachar 1987). The addition of malt flour before roller drying has, however, been found to affect the protein quality of the food (Venkat Rao et al. 1976).

Nutritive Value

The protein score of the weaning food, calculated according to FAO/WHO (1973) reference pattern, was 70 (Table 2). The protein quality of the weaning food was evaluated using rat feeding trials. Table 3 shows the protein efficiency ratio (PER), net protein utilization (NPU), biological value (BV), and true digestibility (TD) values of the weaning food protein at a 10% level of protein intake. The weaning food protein was slightly deficient in threonine;

Table 2. Some essential amino acids and available lysine content (g/16g N) of malted weaning food (MWF), malted weaning food containing 10% milk powder (MWFM), and a proprietary weaning food (PWF).

Amino acids	MWF		MWFM		PWF		FAO/WHO (1973) reference pattern
	Content	Chemical score	Content	Chemical score	Content	Chemical score	
Lysine	5.3	98	5.6	102	5.6	102	5.5
Tryptophan	1.3	134	1.3	134	1.4	142	1.0
Threonine	2.8	70	3.0	75	3.1	78	4.0
Methionine and cystine	4.2	121	4.1	118	3.8	107	3.5
Available lysine	4.5	–	4.9	–	4.3	–	–

when the food was supplemented with 10% skim milk powder, the PER was enhanced to 2.7, and the NPU to 63.0 (Malleshi, Desikachar et al. 1986).

The blend, adequately fortified with vitamins and minerals, was fed as supplementary food (70-80 g/day per child) for a period of 6 months to children from 8 months to 3 years in a hospital, in an orphanage, and in a labour crèche. The children readily accepted and tolerated the blend. The data on body-weight increase and on blood composition indicated the growth-promoting value of the food (Venkat Rao et al. 1985) (Table 4). The breath-hydrogen estimation after intake of the weaning food indicated that the food does not produce flatus (Savitri 1986). It can therefore be recommended for convalescent and geriatric subjects as well as for children.

The weaning food is not hygroscopic. Its critical moisture and RH at 25°C were 11 and 65%, respectively. The food packed in polythene pouches and stored at ambient storage conditions remained acceptable up to about 5 months. The food may, however, be packed in airtight tins or laminates for longer shelf life, safe storage, and wider distribution (Malleshi 1984).

The preparation of MWF does not require sophisticated equipment: existing cereal-processing machinery, such as a plate grinder mill or huller mill, could be used to process the malted grains. The cost of the weaning food would be around INR 15/kg (in 1987, 13 Indian rupees [INR] = 1 United States dollar [USD]) - almost half that of the proprietary weaning foods marketed in India. Several trial batches (100-200 kg) of the food were produced at the Central Food Technological Research Institute (CFTRI), in a village, and at an orphanage. The process was demonstrated to several volunteer organizations, and the 'know-how' released for commercial exploitation.

Studies were conducted at CFTRI in the early 1960s, to investigate the use of malted cereals in weaning food formulations. Using rat-feeding trials, two formulations - malted sorghum, wheat, and finger millet, blended with low-fat peanut flour (Chandrasekhara et al. 1957), and finger millet malt flour, blended with low-fat oilseed flour and chickpea flour (Korula et al. 1961) - were analyzed for their nutritive value. The reports indicate that these formulations had growth-promoting value. Their protein content was, however, rather high (24-36%). Gopaldas et al. (1982), from M.S. University, Baroda, compared the overall qualities of weaning-food formulations based on malted and on roasted wheat; they reported that the formulation based on malted wheat was readily accepted by children, and that the food intake was higher for the malt-based formulation than for the roasted wheat-based formulation. Mosha and Svanberg (1983) (from the Tanzania Food and Nutrition Centre, Tanzania, and Gothenburg University, Sweden, respectively) conducted exploratory studies on the use of germinated sorghum and maize in weaning foods. They reported that the gruels based on sprouted maize and sorghum had very low viscosity, as compared with gruels prepared from the corresponding raw cereals. For reduction of bulk, they also advocated the use of malted cereal flours, to be added while the gruel is hot and stirred up.

Daodu (1986) studied the development of weaning-food formulations based on sorghum and cowpea, and reported that the formulation based

Table 3. PER, NPU, BV, TD, and RPV values of malted weaning food protein (MWF).

Particulars	MWF	MWFM[a]	PWF[b]
Protein efficiency ratio[c]	2.2	2.7	2.3
Net protein utilization[c]	51.6	63.4	62.0
Biological value[c]	73.8	-	79.2
True digestibility[c]	82.8	-	79.2
Relative protein value[d]	84.0	-	88.0

[a] MWFM, malted weaning food containing 10% milk powder.
[b] PWF, proprietary weaning food.
[c] At 10% level of protein intake.
[d] At 5, 8, and 11% levels of protein intake.

Table 4. Body weight and blood composition of infants and weaned children fed on malted weaning food (MWF) and on a proprietary weaning food (PWF).

	MWF				PWF			
	Initial		After 6 months		Initial		After 6 months	
Particulars	A	B	A	B	A	B	A	B
Weight (kg)	7.5	8.8	8.8	10.6	7.6	8.3	8.9	10.0
Hemoglobin (g%)	11.1	9.2	13.1	11.7	12.3	9.9	11.8	9.0
Total protein in blood plasma (g%)	6.5	6.1	6.9	6.9	6.9	6.4	6.6	6.9
Plasma albumin (g%)	3.8	3.5	4.1	3.6	4.0	3.5	4.0	3.7

Note: A, infants (8-11 months old); B, weaned children (1-3 years old). Average of five children in each group, fed for a 6-month period.

on malted sorghum and cowpea had higher PER (2.4) than that of roller-dried food prepared from raw sorghum and cowpea (1.7). Exploratory studies carried out at CFTRI on the use of malted maize (Nghi 1987) and rice (Capanzana 1987) also indicate that malted cereal, considered either as a base material or as a source of amylase for the reduction of dietary bulk, holds promise for use in weaning-food formulation.

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WEANING FOODS IN NEPAL

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Abstract *Undernutrition is one of the major problems confronting infants and young children in developing countries such as Nepal. The problem arises from two factors: an inadequacy in the supply of food needed for infants and children; and ineffective utilization of such foods as are available. The weaning period is a critical one in child feeding; appropriate complementation during this period is essential to the nutritional well-being of the child. The paper discusses this aspect of infant feeding, both in terms of the content of complementary food, and of the timing of the initiation of weaning. A description is given of the simplest of the weaning foods - "sarbottam pitho," or "super flour," patterned after "sattu," a traditional Nepalese food. A weaning food development project was undertaken in 1980 by the Central Food Research Laboratory in Nepal. The objective of this project was the development and promotion of malted, ready-to-eat multimixes that would utilize the traditional process of germination, and that would take advantage of cheap, locally available cereals and legumes (pulses). The project involved training, demonstrations, and the use of mass media. Further evaluations are required, however, to determine the degree to which the technology has been adopted by village families.*

The Kingdom of Nepal, bordered by China in the north and by India in the south, east, and west, has a total land area of about 147,181 km^2, consisting of three well-defined physiogeographical belts running east to west: the terai (75-300 m above sea level), the middle hills (300-3000 m above sea level), and the mountains (3000-8000 m above sea level). The flat plains of the terai, although making up only 17% of the total land area, have 65% of the arable land and 38% of the population. The middle hills, constituting 68% of the land area, have only 30% of the arable land, but 56% of the population. The mountains have about 10% of the population and 15% of the land area. Because of the snow coverage, the mountain areas are of little agricultural importance.

Variations in elevation, cloud cover, and topography result in a wide variation in ecological conditions. The prevalence of numerous microclimates permits the cultivation of a variety of crops. Maize commands the highest proportion of total harvested cereal area, followed by paddy and wheat in the hills; paddy is predominant in the terai. Although only 16% of the land is considered suitable for cultivation, agriculture is the principal occupation of more than 90% of the population, and contributes up to 60% of the gross domestic product (GDP).

In Nepal, 85% of the cropped area is under cereals - paddy, maize, wheat, millet, and barley. Sugarcane, potatoes, and oil seeds are the principal cash crops. The cereal consumption pattern varies widely between the hills and the terai: in the latter, rice occupies first place; maize is the staple in the hills. Millet and barley constitute about 10% of cereal consumption in the hills, but only 3% in the terai. More than 80% of the diet is cereal-based.

With a per capita income of USD 160 per annum, Nepal is one of the poorest countries in the world. The harsh life in a rugged topography, together with poor social and economic conditions, gives rise to some of the highest existing rates of malnutrition, as well as to widespread infection. What has been called the "agricultural crisis" has manifested itself in the inability of a declining agricultural production to feed an ever-growing population: the current population (predominantly rural, with almost 94% residing in the rural areas) is estimated at more than 15 million, and the growth rate at 2.7%. More than 40% of this population live below the poverty line; more than 80% of the women and approximately 60% of the men are illiterate.

Nutritional Problems and Infant Feeding Practices

Children form a large and increasing proportion of the Nepalese population. According to the 1981 census, there were 2.31 million young children 0-4 years of age, making up 15.41% of the total population. Infant and child mortality is, however, extremely high, ranging from 100-300 and 160-360/1000 live births, respectively. High morbidity and mortality among children is the combined result of malnutrition, infections, and lack of basic health care and other social services. Being one of the poorest countries in the world, Nepal has all the characteristics of a least-developed country.

The prevalence of wasting and stunting among children (under the age of 6 years) is alarmingly high: the 1975 Nepal National Nutritional Status Survey revealed, for example, that 51.9% were stunted, 6.6% wasted, and 3.8% both wasted and stunted. Comparison with a relatively well-off group of children selected from Kathmandu shows clearly the gap in nutritional status between socioeconomic classes: stunting, wasting, and concurrent wasting and stunting in this special group were determined to be 18.8, 1.9, and 0.6%, respectively.

In addition to anthropometric indicators of nutritional status, specific nutritional deficiencies, including anemia, xerophthalmia, and goitre have been identified in various population groups in Nepal. More recent nutritional status surveys of children 0-5 years of age indicated a high prevalence both of moderate and of severe degrees of malnutrition.

In Nepal, the distribution of wasting by age group indicates that infants and children up to 35 months of age are the most seriously affected. This pattern could indicate general maternal inability to provide adequate milk, poor quantity and quality of weaning food, and the young child's inability to compete successfully for the family food. Stunting is found at a very early age in Nepal. It is likely that those children stunted early will remain permanently behind in linear growth.

As with each succeeding year the child fails to obtain nourishment adequate both for growth and for day-to-day nutrition, he or she slips into the "stunted" category. One of the major problems confronting infants and children in developing countries such as Nepal is therefore malnutrition, or undernutrition. This problem stems from two factors: the first is an inadequacy in the supply of food needed for infants and children; the second is an ineffective utilization of such foods as are available.

Weaning Processes

During the early months of life, breast milk is usually the only food given to the child. Because breastfeeding provides all the nutrients an infant needs for the first few months of life, the period between 1 month and 4 and 6 months of age is relatively safe. Even with the best lactation performance, however, breastfeeding becomes inadequate after 4-6 months, and supplementary feeding becomes necessary; the baby then begins a gradual "weaning period."

A major challenge common to all human societies is the securing of a "safe passage" for the infant, from birth to the time when he or she can consume the normal family diet and become physically independent. Between 4 and 6 months (depending on the growth of the individual baby), semisolid and, later, solid foods must be introduced progressively; breastfeeding should be continued for as long as possible. Until the child can eat the regular family diet, specially prepared foods will be needed in increasing quantity and variety.

Weaning is, therefore, an important period of adaptation from breast milk, a food that satisfies all the nutritional needs of the infant for the first few months, to a mixed diet containing solid foods.

The process of transition from infancy and total reliance on breast milk to childhood and the ability to survive on the family diet is not only a matter of physiological maturation. Over the first 24-30 months of growth, anatomical and physiological developments in the gastrointestinal and enzyme systems (permitting the child to consume adult food) are paralleled by other physical and developmental changes: communication skills increase rapidly, such that by the end of this period, many children are able, albeit simplistically, to verbalize many of their needs and feelings; mobility also improves dramatically during this period and, combined with the consumption of new foods, makes the child more vulnerable to illness caused by infection.

Appropriate complementary feeding during the weaning period is a complex aspect of child feeding, and is critical to nutritional well-being. In infancy, growth is more rapid than at any period of life; nutritive requirements per unit of body weight are also greater. Good food sources of energy, protein, calcium, and iron are particularly important during this time. On the basis of body weight, children require twice as much protein, calcium, and iron as do adults.

Weaning Practices

In Nepal, complementary foods have traditionally been of low caloric density and low protein content, containing little or no fat, and often limited in micronutrients. Such foods are not well suited as supplements to the breastfed infant's diet. Moreover, supplementary feeding is usually initiated too late and in quantities that are inadequate. As a result of all these factors, infants are commonly half-starved from 6-12 months of age. After this point, they begin to partake of the family diet, in which the main foods are usually rice, maize, or tubers. Although their needs are greatest, they receive the smallest share of the protein supplements. At the same time, they are seldom encouraged to eat vegetables, and their diet therefore becomes dangerously overdependent on rice or on some other staple. Appetite then begins to fail, and infection perhaps tips the scale by causing further dietary restrictions and the loss, in loose bowel motions, of valuable nutrients.

During the period of the sixth plan, a study of weaning practices was conducted in 10 districts of Nepal by the Nutrition Section of the Central Food Research Laboratory (CFRL). This study showed that, although breastfeeding is universal, no particular weaning foods are used by the rural population. Foods such as "dal bhat" (rice-pulse) and "dhindo" (traditional corn meal), usually consumed by adults, are given in small amounts and in diluted form to young children (6-36 months). Sour and cold foods are restricted. Roasted and ground soybeans, or corn and flattened rice moistened with water, are also given as snack foods. These adult foods are very difficult for a child to digest, and therefore cause diarrhea. Infants and young children may receive food left over from an earlier meal; because of improper and inadequate storage, these leftovers are often heavily contaminated (CFRL 1987).

In some societies, especially in the Kathmandu valley, "pasne" is observed: this is the rice-feeding ritual that takes place when the child is 5-6 months of age. On this ceremonial day, "kheer," a special rice preparation with milk and sugar, is served to the infant as a first solid food. After this, infants and toddlers are fed with "lito," a traditional bland rice porridge made with clarified butter (ghee) and sugar (if these are available).

Rice "lito" or gruel is deficient in protein and vitamins. The starch granules in rice flour or grains not only swell on cooking, but show a great propensity for holding and binding water. This contributes to the typical dietary bulk of a rice gruel, and therefore to the low caloric density per unit volume consumed. Infants and young children from 6 to 36 months of age cannot ingest sufficient amounts of such preparations to fulfill their energy requirements. When the caloric needs are not met, growth is retarded, and the body begins to break down its own protein to supply energy. Most starchy staples supply incomplete protein; if breastfeeding is inadequate, the situation is made worse, resulting in protein energy malnutrition (PEM) - one of the major nutritional problems in Nepal.

Whereas protein of animal origin is costly and in short supply, beans (legumes) or seeds can complement cereals to increase the protein available from vegetable sources. Although it is not prepared daily, "jaulo" is a traditional weaning food made from rice, lentils, and green vegetables and intended for convalescing young children and for the elderly. Feeding two or three times a day is, however, insufficient: the volume that a child can consume at each serving is too little to meet his or her nutritional requirements.

Despite the general availability of cereal grains and pulses for the provision of an adequate and balanced diet, most children do not consume enough calories. Customs surrounding food prevent the utilization of that food for weaning children. Such customs may have developed because of the difficulty for a young child of digesting inadequately cooked vegetable protein.

In many traditional societies, the weaning child seldom receives specially formulated foods: rather, he or she is gradually introduced to adult foods. The child, whose stomach is small, cannot consume enough food to supply the nutrients necessary for growth and development. The inappropriate and nutritionally poor diet given to the children results in growth retardation and in infection; diarrhea and other infections are responsible for the high mortality and morbidity of infants and young children.

There is an urgent need to develop satisfactory, cheap, and culturally acceptable weaning foods that can be prepared from locally available resources and that are therefore accessible to the lower-income socioeconomic classes. From the nutritional point of view, and in view of the infant's limited gastric capacity, the concentration of energy and nutrients is an important characteristic of weaning foods. These foods should be soft (so that they are easy on the babies' digestive tracts) and free of contamination.

Low-Cost Weaning Foods

A Nepalese traditional food preparation called "sattu," an instant food, is used especially in the tarai; an age-old method is employed, whereby the roasted ingredients of cereals and legumes are ground into a powder and mixed with water to make a thin gruel or cake.

Patterned after "sattu," "sarbottam pitho" was developed by the Shanta Bhavan Community Health Program in Nepal. This is a "super flour" that provides an excellent supplementary food for infants and young children. It combines local beans and whole, dried cereal grains, roasted and ground into a powder. This powder is cooked as a porridge, with enough water for the desired consistency. Home-prepared "sarbottam pitho" is the simplest weaning food and generally has two ingredients - a cereal and a legume, in a 1:1 ratio. This basic mix becomes, with the addition of fat, oil, sugar, or a vegetable in suitable proportions, a multimix, constituting a complete meal. It cannot, however, be recommended unequivocally for the continuous feeding of children 6-36 months of age: because it exhibits high viscosity and high protein content, one cannot be sure of its digestibility; it is therefore considered more suitable for older, preschool children (Desikachar 1980).

Malted Multimixes

The search has been ongoing for a low-cost weaning food that would combine at least some of the following characteristics: high-nutrient density; low-bulk properties; utilization of widely used, cheap, and locally available cereals, pulses, and oil seeds; and use of improved traditional processing methods that can be easily adopted at the home or village level. This search led to the development of malted multimixes. The evidence of Desikachar (1980) showed that malted, ready-to-eat mixes have considerable advantages over mixes that are roasted. An enormous amount of work has been carried out and documented, with respect to the science and technology of such processing and its effects on nutritive value, culinary qualities, etc. In-depth studies were conducted by Desikachar (1980), a WHO consultant at the Central Food Technological Research Institute (CFTRI), Mysore, India; Tara Gopaldas (1982) of the Food and Nutrition Department of the Maharaja Sayajrao University, Baroda, India; and our own researchers at the Nutritional Research and Development Division of CFRL, Nepal. These studies clearly indicate the tremendous potential of malted cereal-pulse or oil seed multimixes in weaning-food formulation; this potential is enhanced by the fact that germination of cereal and legume grains is a traditional and universal practice in Nepal. Millet and green gram were used originally as the raw materials; since then, we have been conducting studies with different cereals and legumes.

The studies employ common household methods of processing or pretreatment: these methods include soaking, germination, malting, cooking (roasting), and milling. All these processes modify, both qualitatively and quantitatively, the nutritive value of the food. They have also been reported to impart the following beneficial effects: elimination of complex interfering (toxic) substances; increase in shelf life, acceptability (aroma), and digestibility; and reduction in bulk or viscosity to a level necessary to achieve the appropriate caloric density. The proportion of cereal to pulse (bean) is kept simple: a 2:1 ratio is maintained, based on the rough ratio of staple to legume in the average Nepalese diet ("dal bhat"). (The ultimate purpose of the project, after all, was to transfer the technology to the household and village level.) More than one cereal is recommended; some 10 recipes have been developed, using varieties of cereals and legumes, and taking into account their availability in different ecological regions.

The main steps involved in the process are steeping, germination, roasting, and milling. The final product can be packed in polythene bags or in clean, dry, glass containers. The proximate composition of these formulations of malted mixes reveal that they are within the acceptable limits of 350 kcal and 12-15 g protein/100 g (20 g/100 mL gruel, or 0.7 kcal/mL).

Both the acceptability test and the feeding trial were conducted in Dhading, one of the hill districts in the central region of the country. Forty-two mothers and their weaning-age children participated. A 3-month feeding trial was conducted with the cooperation of the local health post; growth charts were produced through a bimonthly monitoring of the children.

The food preparations were found palatable and acceptable. After continuous feeding for 3 months, a significant improvement was shown by all those children of the scheduled class and of the low-income group who were suffering from undernutrition. None of these children showed vomiting or diarrhea. Because of our limitations, the animal feeding trial could not be done. The storage test did not give good results. The food was found to have a shelf life of only about 4 weeks (CFRL 1987). A great deal more research needs to be carried out in these areas.

Promotion of Home-Processed Weaning Foods

There are no commercially produced weaning foods in Nepal; they must be imported. The imported products (mostly Indian) are too expensive to be affordable even to the urban, middle-class population. For the rural sector, the majority of whom belong to the low-income groups who are actually the target population, there is no alternative than to develop and promote low-cost, home-processed weaning foods based on locally available ingredients and on traditional methods.

One of the most promising approaches for overcoming weaning-period malnutrition is the development of weaning foods that can be prepared by mothers at the home or village level; this development ideally uses local initiatives and locally available foods and employs traditional processing techniques.

The germination and malting of grains has emerged as a most promising method of weaning-food preparation, both for the reduction of dietary bulk in high-carbohydrate weaning diets, and for the enhancement of the nutrient content of the foods. Because the ultimate purpose of our project was to transfer this simple technology to the households and villages, the following preconditions were taken into consideration:

- The weaning foods should be based on a staple diet ("dal bhat") of cereal and legume;
- Locally available ingredients should be used that are low-cost and therefore affordable to the low-income socioeconomic strata;
- Processing should involve simple, adaptable, and traditional technologies, such as soaking, germinating, malting, drying, roasting, and milling. These methods require only simple household equipment;
- The processing methods should be culturally acceptable;
- The foods should be nutritionally adequate as supplements to breast milk;
- The foods should be soft in texture, low in fibre content, and high in caloric density;

- They should be foods that can be precooked, therefore needing only minimum cooking before being served to the children; and

- They should be acceptable and easily digestible, without producing secondary disorders such as diarrhea, vomiting, and flatus.

Germination (an intermediate step in malting) of cereals or of legumes has been shown to cause increases in thiamin, riboflavin, niacin, folic acid, ascorbic acid, iron, amylase and diastase activity, protease activity, digestibility, protein efficiency ratio, and biological value. Germination also has been shown to increase caloric density and to reduce viscosity, with decreases in phytin and increased phosphorous and trypsin activity of hemagglutinin.

Roasting precooks the ingredients used in cereal-legume mixes and increases the shelf life and acceptability. Most antinutritional or toxic effects of legumes (trypsin inhibitor, hemagglutinin, goitrogenic agents, cyanogenic glucosides, alkaloides, etc.) were partially or wholly eliminated by roasting.

The weaning period is a critical one, during which the infant is extremely vulnerable: inadequate or improper nutrition during this period may lead to severe malnutrition. Despite the rather lengthy and laborious preparation required (steeping, germination, roasting, and milling), the virtues of sprouting and malting of grains, and the superiority of malted multimixes over their roasted counterparts, make it more than worthwhile to incorporate these processes into the development and promotion of home- and village-prepared weaning foods. The processes of sprouting and malting are not new to the Nepalese. The traditional food "quanti," a semiviscous soup, is prepared from germinated mixtures of varieties of legumes; this food is eaten during a festival called "Janai Purnima," in the month of August. This is the month when diarrheal infections are rampant; "quanti" could therefore be used as a therapeutic food.

Roasted cereals and beans have been the traditional snacks of the Nepalese; special mixes of roasted grains are sometimes eaten as festival crackers. "Astamandap," a super flour made from a mixture of cereals and legumes, is a food prepared specifically for old people and convalescents; its preparation involves all the above-mentioned processes. There is therefore no reason why the benefits and use of malted mixes should not be encouraged and popularized through extension services such as demonstrations and the training and education of mothers, rural women, volunteers, and community workers.

Changes do not come easily; the means are therefore critical whereby a weaning intervention is presented to the target population. The development of programs to effect changes in weaning behaviour is a complex task: home- and village-based programs require the sustained efforts of nutritionists, home scientists, and nutrition educators.

His Majesty's Government, Nepal, with the support of UNICEF/WHO, initiated the Joint Nutrition Support Programme (JNSP) in 1983/84, in five selected districts; the program was designed to have a multisectoral approach. This is the country's first effort to make manifest the concept of an integrated approach to a single nutrition program. Promotion of home- and village-processed weaning foods through demonstrations and educational programs for mothers is one of the very important activities undertaken by the Nutritional Research and Development Division of CFRL. This training is also designed for female community workers.

During the last 3 years, demonstrations and training sessions have been organized and conducted in different villages; these sessions have involved mothers in the preparation, under local conditions and using local equipment and materials, of weaning foods based on malted multimixes. In the tarai, the multimixes based on rice, wheat, and bengal gram are being popularized; in the hills, the focus is on rice, corn, and soybean, depending on the general availability and dietary pattern. The demonstrations and training sessions were conducted in local health posts and centres that maintain the growth-monitoring charts. After training, each participant is advised to form a mothers' club and teach others what she has learned; in this way, information can be more effectively disseminated.

This program of demonstration and training has so far been conducted in three hilly districts and in two terai districts in different panchayats. Some 250 women have been trained. The trainers include a nutritionist, a home scientist, an agriculturalist, and a health assistant. Guest lecturers, such as local women development officers and family planning officers, have also participated.

The program has been well attended. Because food preparation was based on traditional methods of processing, the mothers were able to benefit from new practices based on age-old methods. Because the demonstrations involved practical training of the homemakers, they were appealing to the rural women. A simple survey must, however, be undertaken to determine the degree to which these new practices have been adopted by village families. It is also important to realize that without the correct motivation, knowledge alone may not improve the mothers' methods.

The adoption of "sarbottam pitho" (super flour) was evaluated in Tansen, a hill area of western Nepal. It was found that 67.1% claimed to have heard of "sarbottam pitho," and 13.28% said they had made it at home. A survey conducted in five districts indicated that "sarbottam pitho" was given to 34% of the children in the Makwanpur (inner terai) district, but to less than 2% in the other four districts.

There appear to be two major stumbling blocks with regard to the use of this food: many families are too poor to be able to afford it; and those mothers who breastfeed their children for 2 years are often unaware of the importance of weaning foods. With little extra time available to them, the mothers complain of the length and tediousness of the processing. Once these mothers become motivated (once they become aware of the nutritional needs of their children), the translation of the technological knowledge into practice becomes easier and more natural. If, however, the families are too poor, or are not in a position to prepare two meals per day, other interventions, both immediate and long-term, are required.

Although the composition of new weaning foods (with ingredients that are low in cost and available year-round) is extremely important, communication about nutrition is the key to a successful introduction of these foods. Weaning-food development should be a part of mother-and-child health services or of primary health care.

Conclusions

There are no commercially produced weaning foods in Nepal. The marketed products are all imported and too expensive to be affordable, even to the urban middle class, to say little of the majority of the rural households, who are socioeconomically very backward. The approach that encourages home-preparation and processing of weaning foods has the advantage of allowing for intervention at multiple points in the nutritional system and of being applicable, in some degree, to all segments of society.

There should be promotion and support of local ingredients, prepared in the traditional manner as home-made weaning foods; this is an important part of a nutritional strategy for improved child feeding and nutritional well-being.

The foods chosen for weaning recipes should be easily available from gardens or local markets, low in cost, and used frequently in most households.

Effective demonstrations are required to motivate and involve the mothers and thus to make them aware of the nutritional needs of their children. In this way, the translation of technology into practice will become easier and more natural.

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CYANIDE CONTENT OF GERMINATED CEREALS AND INFLUENCE OF PROCESSING TECHNIQUES

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Abstract *A recent paper stated that dried products from germinated sorghum contained hydrocyanic acid and were, therefore, potentially hazardous to the consumer. Work at the Overseas Development Natural Resources Institute (ODNRI) has refuted this statement (Dada and Dendy 1987). Germinated feterita sorghum, containing an average of 454 ppm cyanide as HCN, was used as a substrate. When this was dried at 50°C, little effect was had on the HCN level. It was found, however, that when the sorghum was toasted at 100 or 180°C for 15 min, and then dried at 50°C, the hydrocyanic acid (HCN) level was lowered by 83 and 96.5%, respectively. Fermentation of either a paste or a slurry of germinated sorghum for 24 h resulted in a loss of HCN in excess of 70%. Boiling the slurry or steaming the paste eliminated the HCN completely. Frying or hot-grilling the paste removed slightly more than 90% of the HCN. The Tanzanian infant food "kimea" was also studied. It was shown that during the normal process of making this food, there was a lowering to a safe level of the cyanide in the sprouted sorghum. There was no cyanide in sprouted pearl millet. In a preliminary study, no correlation was found between the tannin content of the grain and the HCN content after germination.*

Sorghum is a major source of human food in semi-arid regions that include much of eastern and southern Africa. Sorghum can be converted into excellent foods, both traditional and new, by suitable processing; this processing can also be industrialized, and the food sold in convenient retail packs. Products such as "uji" (thin porridge) and "supa mtama" (polished sorghum) are already available across the counter.

The sprouting of cereal grains results in increased enzyme activity that in turn causes the following: loss of total dry matter; change in amino acid composition; conversion of some starch to soluble sugars; slight increase in crude fat and crude fibre; and slightly higher amounts of certain vitamins and minerals (Morard and Rubenthaler 1983). Wang and Fields' (1978) suggestion that sorghum be germinated in the home was opposed by Panasiuk and Bills (1984): they considered the potential for cyanide poisoning and noted that both germinated sorghum and young sorghum plants contain appreciable amounts of the cyanogenic glycoside 'dhurrin' - a substance that, upon hydrolysis, yields hydrocyanic acid (HCN); ungerminated sorghum grain contains little or no dhurrin.

The lethal dose for HCN is 0.25-3.5 mg/kg body weight, depending on the individual; the median dose would be approximately 1 mg/kg. If a sorghum product contains 400 ppm of HCN, then the lethal ingestion would be 25 g (dwb) for a 10-kg infant. Neither should we overlook the goitrogenic effects of the ingestion of sublethal doses of HCN over a long period.

Traditional processes generally include the drying and milling of germinated sorghum to produce a sorghum malt. This malt can be used as an ingredient for the production of foods such as porridge, alcoholic or nonalcoholic beverages, and unleavened bread. Germinated sorghum can also be wet-milled into a paste or a slurry that can be further fermented before it is boiled, steamed, fried, or baked. Several authors have published accounts of traditional methods of processing sorghum in a number of countries; examples of such studies are those of Subramanian and Jambunathan (1980) and of Rooney (1984).

The main objective of this investigation was to determine the effect of traditional processing on the cyanide content of germinated sorghum. An opportunity later arose to cooperate with the United Nations Children's Fund (UNICEF) in Tanzania on the examination of an indigenous infant food, "kimea," made by adding a sprouted grain (sorghum, finger millet, or pearl millet) to a maize porridge.

Materials and Methods

Grain

The work was done in the ODNRI laboratories. Feterita sorghum was obtained commercially in the U.K. Through the offices of UNICEF in Dar es Salaam (Tanzania), ungerminated samples of white sorghum, "Serena" variety sorghum, and pearl (bulrush, pennisetum) millet were obtained from Dodoma, and finger millet (ragi, eleusine) from Sumbawanga. UNICEF also supplied sprouted samples of these grains as used in "kimea." To destroy a minor infestation of weevils, the samples were held at -30°C from arrival to use - about 12 days. Commercial maize meal was obtained by UNICEF. The grains are listed in Table 1.

Germinated Grain

Cleaned, whole grain was soaked in four times its volume of water at ambient temperature (20°C) for 24 h; it was then sprouted on a sprouting tray at 30°C in a humidity oven (RH 95%) for 2 days. The grain was washed twice daily with water during sprouting to prevent mould growth. This was considered the laboratory equivalent of the traditional germinating of grain. The laboratory samples were divided and further processed into three groups: malt meal, wet-milled products, and dry-milled products.

Table 1. HCN content of grains and malts.

	ppm HCN[a]
Grains (unsprouted)	
White sorghum ex Dodoma	ND[b]
Serena sorghum ex Dodoma	Trace[c]
Pearl millet ex Dodoma	ND
Finger millet ex Sumbawanga	ND
Sprouted grains	
Sprouted at ODNRI	
Feterita	454
White CV sorghum ex Dodoma	413
Serena CV sorghum ex Dodoma	122
Pearl millet ex Dodoma	ND
Finger millet ex Sumbawanga	ND
Sprouted in Tanzania, analyzed at ODNRI	
White sorghum ex Dodoma	12
Serena sorghum ex Dodoma	41
Bulrush millet ex Dodoma	ND
Finger millet ex Sumbawanga	ND

[a] Average of duplicates.
[b] Not detectable.
[c] Below 5 ppm.

Malt Meal

Malt meal was prepared by drying the germinated grain in an air oven at 50°C for 24 h. A form of toasting was carried out to enhance the flavour of the meal: air heated to temperatures of 100 and 180°C was passed through thin layers of the grain for 15 min. (Various combinations of drying and toasting were used (see Table 2).) After the grain had been rubbed on a sieve and the shoots and roots (growth) either retained or removed, the hammer-milling was done.

Wet-Milled Products

Wet-milled products were prepared using a mortar and pestle to grind the germinated grain with varying amounts of water; this produced either a paste or a slurry. Some of these products were fermented for 24 h at room temperature. The fermented slurry was boiled for 15 min, and the paste either steamed or fried in oil for the same length of time.

Dry-Milled Products

Dry-milled products were prepared by drying and milling the germinated grains. Samples of malt were made into a dough and toasted or boiled with water. The boiled malt was cooled, then fermented (mainly lactic acid fermentation).

"Kimea" Infant Food

To prepare the infant food, a stiff maize meal porridge was made by adding 100 g maize meal to 400 g water. This was brought to a boil and cooked for 30 s before stirring in 10 g of the germinated, dried

Table 2. HCN content of food products.

	ppm HCN
Malt meal	
Dried at 50°C and milled	446
Dried at 50°C minus growth and milled	45
Dried at 50°C, toasted at 100°C, and milled	321
Dried at 50°C, toasted at 100°C minus growth, and milled	43
Dried at 50°C, toasted at 180°C, and milled	46
Dried at 50°C, toasted at 180°C minus growth, and milled	16
Toasted at 100°C, dried at 50°C, and milled	77
Toasted at 100°C, dried at 50°C minus growth, and milled	16
Toasted at 180°C, dried at 50°C, and milled	16
Toasted at 180°C, dried at 50°C minus growth, and milled	0
Wet-milled products from germinated grains including growth	
Wet-milled into a paste and steamed	0
Wet-milled into a paste and fermented for 24 h	119
Wet-milled into a paste, fermented for 24 h, and steamed	0
Wet-milled into a paste and fried in oil	30
Wet-milled into a paste, fermented for 24 h, and fried in oil	0
Wet-milled, sieved, and slurry fermented for 24 h	122
Wet-milled, sieved, and slurry fermented for 24 h, and boiled	0
Dry-milled products from germinated grains including growth	
Dried at 50°C, milled, and boiled in water	0
Dried at 50°C, toasted at 180°C, milled, and boiled in water	0
Dried at 50°C, milled, kneaded into dough, and hot-grilled	30
Dried at 50°C, milled, boiled with water, sieved, wort-boiled and inoculated with yeast, and fermented for 24 h	0
Dried at 50°C, milled, boiled with water, and fermented for 24 h	0
"Kimea" (UNICEF samples)	
White sorghum after cooking	ND
White sorghum after cooling to 60°C	ND
White sorghum after cooling to 40°C	ND
Serena sorghum after cooking	ND
Serena sorghum after cooling to 60°C	ND
Serena sorghum after cooling to 40°C	ND
"Kimea" (ODNRI-sprouted samples)	
White sorghum after cooking	Trace
White sorghum after cooling to 60°C	Trace
White sorghum after cooling to 40°C	Trace
Serena sorghum after cooking	ND
Serena sorghum after cooling to 60°C	ND
Serena sorghum after cooling to 40°C	Trace

ground grains ("kimea"). Samples were taken at once and during natural cooling at 60 and 40°C.

Hydrocyanic Acid (HCN)

HCN was determined by the AACC method (1983), with minor modifications for distilling the homogenate. A Kjeltec Distilling Unit 1002 was used to ensure that HCN from the sample was not liberated into the atmosphere. The products from the original 10 g dry sorghum grain were blended with 100 mL water and transferred into a distillation tube that was then sealed. After standing for 2 h, 20 mL of 10% tartaric acid was added, and the steam switched on. The liberated HCN was collected quantitatively in 50 mL of 2.5% NaOH. When 400 mL of the distillate had collected in the receiver flask, it was titrated with 0.2% silver nitrate by the AACC approved method (60-20). Blank determinations were also carried out.

Results and Discussion

Table 1 summarizes the data on HCN recoveries from the various grains, and Table 2 summarizes that recovered from the food products. These data show that millet grain and sprouts supplied by UNICEF did not contain any trace of cyanide. The same result was obtained when the millet grain was sprouted at ODNRI. This is a clear indication of the likely absence of cyanogenic glycoside in millet. Although Serena CV sorghum grain did contain cyanide, the amounts were very small. No cyanide was detected in the white sorghum grain.

Germinated sorghum, dried at 50°C and milled to make a malt meal that could be used as a food ingredient, did not lower significantly the dangerously high level of HCN. This endorses the conclusions of Panasiuk and Bills (1984). Toasting the malt at 100°C lowered the HCN content only slightly; toasting at 180°C, however,lowered the HCN content by 90%. Toasting wet-germinated sorghum for 15 min at 100°C, or at 180°C, resulted in a loss of 83 and 96.5%, respectively. The removal of the shoots and roots lowered the HCN content by more than 90% (Tables 1 and 2). This would indicate the presence of limited amounts of dhurrin in the seed, as compared with the very high level in the shoots and roots of the germinated grain. The shoots and roots were not removed before preparation either of the wet-milled or of the dry-milled products. The levels of HCN were reduced by more than 70 and 90%, by a fermentation of the paste and the slurry, or by a drying and toasting of the paste, respectively.

All the processes used (with the exception of the drying at 50°C and the drying at 50°C followed by toasting at 100°C) reduced the levels of HCN by at least 70% and frequently by 100%; the remaining HCN was therefore always well below 200 ppm - the maximum level recommended in several countries for HCN in lima beans (Panasiuk and Bills 1984).

Wang and Fields (1978) suggested that germinated sorghum could and should be used to produce more nutritious foods. This brief investigation strongly suggests that foods produced from germinated sorghum, either by dry heating to 180°C, by moist heating to 100°C, or by lactic acid or alcoholic fermentation, offer little or no risk of cyanide poisoning.

Germinated sorghum, therefore, has good potential for use in traditional foods or in new, industrialized products. Shortly after the principal part of the program had been completed, there was an opportunity to examine a traditional food, "kimea," provided by UNICEF. The results from this examination are included in the tables. It will be noted that the method for making infant porridge from maize meal, whereby 10% sorghum malt is added, eliminates almost all the HCN present.

Although the addition of high cyanide sorghum sprouts (413 ppm) to hot maize porridge did not totally eliminate the cyanide, the latter was reduced to a reasonably safe level. Adding the sprouted sorghum at a lower temperature would increase the risk of cyanide poisoning. To prevent this, the flour from sorghum sprouts should be added just at the boiling point of the porridge. Assuming that the germinated sorghum obtained in Tanzania had, initially, a similar proportion of HCN to that germinated in the U.K., the HCN level must have been lowered by 90% during the transport period of 2-3 weeks. (In this context, it is worth noting that during the processing of germinating sorghum, dhurrin is hydrolyzed, thus liberating HCN. Care should therefore be taken during processing by, for example, providing good ventilation of the processing area and thus allowing the HCN to be removed without danger.)

Table 3. Relationship between tannin content of sorghum grain and the HCN content of the 2-day sprout (30°C).

		Sprout length (mm)			
Variety	**% germination**	**Range**	**Average**	**% tannin**	**HCN (ppm)**
M-35-1	95.4	1-60	29.6	0.04	200
ET-3491	98.8	1-80	50.3	0.05	643
NES 7360	68.3	1-40	24.0	0.05	145
2KX 17	70.0	1-40	19.2	0.06	197
IS 76	94.0	1-55	41.3	0.06	564
SPV-472	98.5	1-60	40.3	0.06	562
Lulu Dwarf	95.3	1-60	41.3	0.06	594
IS 8595	91.8	1-50	20.2	0.07	286
USA Yellow (old stock)	70.9	1-30	7.2	0.08	74
Local White (Kenya)	95.1	1-30	20.7	0.08	494
WS 1297	90.5	1-40	20.1	0.08	271
Feterita	90.5	1-70	45.2	0.09	454
CO-4	97.6	1-60	42.4	0.20	548
Local Red (Botswana)	81.5	1-50	19.5	0.50	286
Serena	81.0	1-65	24.8	1.65	387
Seredo	95.0	1-65	34.1	2.90	658
Dobbs	99.1	1-70	44.0	3.40	826
Local Red (Kenya)	90.0	1-40	25.0	7.70	200
BJ 28	90.8	1-15	4.9	9.00	308

The study attempted to draw a correlation between the ability of the sorghum variety to generate HCN on sprouting, and the tannin content of that sorghum; the results in Table 3 show that there is no such correlation. These results also show that of the 19 varieties examined, all produce dangerously high levels of HCN on germination. These concentrations of HCN can, however, be lowered to safe levels by the careful use of indigenous methods of processing and cooking.

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IMPROVED IRON AVAILABILITY IN WEANING FOODS THROUGH THE USE OF GERMINATION AND FERMENTATION[1]

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Abstract *Anemia is second only to malnutrition as the most common health problem in Tanzania and in most developing countries. Although malaria is one important causal factor, it seems that iron deficiency anemia is the most common type of anemia in Tanzania. Despite clear indications of its prevalence, however, most dietary surveys have concluded that iron intake in general is adequate. It seems clear, therefore, that the factor of greatest nutritional significance is the bioavailability of the food iron. The staple foods of Tanzania contain factors such as phytic acid and tannins, that strongly inhibit this bioavailability of iron. By using traditional household technologies such as germination and fermentation, as well as soaking, the effect of these inhibitors could be reduced. To measure the iron availability of weaning diets, we developed a rapid and simple in vitro technique; this technique, while providing results that are comparable to those from human studies, is less laborious and costly. We measured the amount of available iron in various staple foods that had been processed by germination or fermentation. We found that both processes, when combined with a modified preparation and cooking procedure, could increase the amount of available iron to 2-6 times that of untreated staple food. The processes involve activation of enzymes that significantly reduce the amount of phytic acid in the foods and thus increase iron availability. The paper emphasizes the significance of this discovery for the development of a practical, household-level approach to the reduction of anemia.*

Anemia is second only to malnutrition as the most common health problem in Tanzania and in most developing countries. For practical purposes, anemia is regarded as that condition in which a hemoglobin concentration exists that is lower than an arbitrarily selected value; it is recognized, however, that because of the overlap between normal and anemic values in a population, such a distinction is a matter of probability. The widely accepted cutoff levels are 130 g/L for men, 120 g/L for women, and 110 g/L for pregnant women and young children (WHO 1968). More severe anemia with microcytosis and hypochromia is indicative of advanced iron deficiency.

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[1] The studies were carried out in collaboration with the Tanzania Food and Nutrition Centre and funded by the Swedish Agency for Research Cooperation with Developing Countries.

Before summarizing the situation with regard to anemia in Tanzania, I will give a general picture of the relative frequency with which different types of anemia appear. The majority of anemias are hypoproliferative, with inflammation, iron deficiency, and acute bleeding being the most common disorders (Hillman and Finch 1985).

The anemia problem in Tanzania has, on the whole, been a concern of general nutritional surveys. The screening test in all these surveys has involved a measurement of the hemoglobin level. The use of a low hemoglobin value as a diagnosis of anemia does not, however, discriminate among possible causes for the anemia. Acute and chronic infection can cause an immediate and significant decrease of the Hb value; this latter, however, is seen only at a late stage in iron deficiency, when iron stores are exhausted. The relative insensitivity of the hemoglobin measurement is also attributable to the wide scatter of values in normal subjects.

Surveys in Tanzania have therefore attempted to elucidate some of the underlying causes of anemia. Data from the nutritional surveys of Tanzania indicate a wide incidence of anemia (Table 1): in some villages, up to 39% of the young children were found to be anemic. In some regions, a significant relationship was found between anemia and malaria, hookworm, and schistosomiasis infections. The effect of minor infections was not, however, investigated; as was mentioned earlier, the prevalence of a real iron-deficiency condition cannot be established with the Hb method.

Sequential changes in the development of iron deficiency are shown by the use of other parameters. From a clinical standpoint, a decrease in storage iron is recognized by a reduction in serum ferritin concentration or by a decrease in stainable iron in the bone marrow, or both. When iron stores are exhausted and a negative iron balance continues, there is a reduction in the supply of iron to the erythroid marrow. This is reflected by a decrease in the saturation of the plasma iron transport protein, transferrin. As a result, hemoglobin synthesis becomes impaired, and there is a rise in red cell protoporphyrin concentration. The restrictions in hemoglobin production eventually lead to a fall in hemoglobin concentration below the cutoff level for the individual.

For a complete picture of an iron deficiency situation, therefore, one must rely on analytical methods that measure the size of the iron stores. In a recent study from the Pawaga division in Tanzania, the protoporphyrin level was measured: about 50% of the children under 5 years of age (n = 651) showed values that indicated an iron deficiency state; more than 90% had an Hb value below the cutoff level, indicating anemia. Indirect evidence also proves iron deficiency to be a major cause of anemia in developing countries: inspection of the data on dietary iron absorption provides strong support for such a conclusion.

Table 1. Anemia by area and population group (from nutrition surveys in Tanzania).

Date	Area	Type of population surveyed	Sample size	Mean Hb g%	Prevalence of anemia (%)	Hb g% cutoff point
1972	Dar	Pregnant women	1317	9.3	100	11
1973	Kilosa	Women all ages	1702	11.2	28	10
1973	Bagamoyo	Women all ages	1467	10.4	15	11.5
1974	Morogoro	Village 0-4 years	31	10.8	-	-
1974	Mbeya	Village 0-4 years	60	11.7	-	-
1974	Tabora	Village adults	328	12.8	-	-
1974	Morogoro	Village adults	323	12.4	-	-
1974	Mbeya	Village adults	336	13.6	-	-
1974	Tabora Morogoro Mbeya	Village adult females	516	12.2	-	-
1979	Rufiji	Village under 5s	288	7.9	-	-
1979/80	Iringa	Village under 5s	1143	11.2	15.9 (0-39)	10
1984	Iringa	Village under 5s	979	11.8	25	10
1984	Iringa	Village under 5s	200	-	25	10

Nature of Dietary Iron

Our knowledge of food-iron absorption has expanded greatly during the last 10 years, and stems particularly from the development of isotopic methods to measure iron absorption from complete meals (Cook et al. 1972; Hallberg and Bjorn-Rasmussen 1972; Layrisse and Martinez-Torres 1972). It is now known that because of separate pathways of entry into the intestinal mucosal cell, dietary iron may be composed of two distinct pools: a pool of hem iron and one of nonhem iron. Hem, providing up to 10-15% of food iron consumed in industrialized countries, consists of the hemoglobin and myoglobin in animal foods. Hem iron is 20-30% absorbed and may account for as much as one-fourth of the iron absorbed from high meat diets. Because hem-iron absorption is little affected by the nature of the meal and only slightly influenced by the iron status of the individual, its contribution can be approximated by chemical measurement of its content in the diet, assuming an absorption of 25%.

Nonhem iron is contained in cereals, pulses, fruits, vegetables, and dairy products; it constitutes the major and, in developing countries, frequently the only source of dietary iron. The absorption of this nonhem iron is highly variable and depends on the nature of the meal. In any given meal containing a combination of foods, a common pool of nonhem iron is formed in the intestinal lumen. The absorption from this pool is determined by the composite effect of factors promoting or impairing iron availability. Factors known to stimulate absorption of nonhem iron are meat, poultry, seafood, and various organic acids, particularly ascorbic acid. A large number of substances are known to impair the absorption of iron: these include polyphenols such as tannins, phytates (Gillooly et al. 1983), certain forms of protein (INACG 1982), and some fibres. Foods that have a strong inhibitory effect on iron absorption therefore include tea, coffee, egg yolk, and bran. Depending on the content of the enhancing and inhibiting substances, absorption of iron from a meal may range from 1 to 40% in individuals with comparable iron status.

Despite the wealth of information available on factors affecting iron absorption from single meals, the information is limited as to absorption from a complete diet. Typical meals in different regions of the world (Hallberg et al. 1983; Narasinga Rao et al. 1983; Acosta et al. 1984) can be separated into three broad categories: low, intermediate, and high bioavailability, with average absorption both from the hem and from the nonhem iron of about 5, 10, and 15%, respectively; this is applicable to an individual with no iron stores but with normal iron transport. There are some diets beyond both extremes of the 5-15% bioavailability range. Iron absorption from diets consisting almost entirely of cereals may therefore be as low as 1-2%; in diets containing large quantities of meat, fish, or poultry, however, absorption may approach 20-25%.

To conclude, all our information indicates that the iron content of cereal-based diets is usually adequate. One should also mention contamination of iron that may contribute up to several times the amount of indigenous iron in the diet; the availability of this is, however, more or less unknown. The availability of the intrinsic iron can vary considerably, from 1 to 40%.

What then are the realistic and practical means of reducing iron deficiency anemia in developing countries? One could consider the following three strategies: the distribution of iron tablets to vulnerable groups, such as young children and pregnant and lactating mothers; the fortification of certain staple foods with iron; and an increase in the bioavailability of the food iron. The first strategy implies an extended and well-functioning MCH system, and the second, a centrally distributed staple food. In many countries, neither of these prerequisites exists. We are left, therefore, with the third strategy: to improve the iron availability of cereal diets. In our collaborative research program with TFNC, we have carried out studies on methods of diminishing the inhibitory effects of phytates and tannins on the iron availability of cereal foods through the use of traditional household techniques such as germination and fermentation.

Germination and Fermentation: Effect on Phytic Acid and Iron Availability

Phytic acid (chemically, inositol-hexa-phosphate) has a strong ability to complex mineral irons such as Fe^{2+} and Fe^{3+}, Zn^{2+}, Mg^{2+}, and Ca^{2+}. These mineral - phytic acid complexes are usually of low solubility and will, therefore, make the minerals unavailable for absorption. In the cereal seed, the phytic acid is distributed mainly in the aleurone layer (Lott and Ockendenen 1986); dehulling the seeds will, therefore, significantly reduce the amount of phytic acids (up to 50-60%). The amounts remaining will, however, still affect the iron availability.

Another way of decreasing the amount of phytic acid in the seed is to activate the phytases that are available in small amounts in nearly all cereal varieties (Nayini and Markakis 1986). The phytic acid is then hydrolyzed into lower inositol-phosphates (penta- to

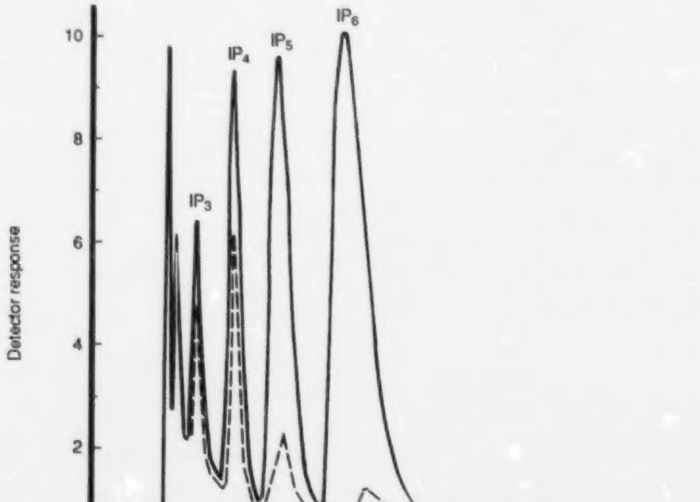

Fig. 1. Relative inositol-phosphate content in soaked (12 h) sorghum samples. ——, ungerminated whole flour; — — —, germinated whole flour. IP_3 to IP_6 = inositol containing 3 to 6 phosphates per inositol residue.

mono-phosphates); as measured in in vitro systems, however, only the hexa- and penta-inositol-phosphates form insoluble complexes with iron. Germination of cereal seeds is also known to increase the phytase activity. We used a new method to measure the inositol-phosphates by extracting in dilute HCl and quantifying using ion-pair chromatography and HPLC (Sandberg and Adherinne 1986). In white sorghum that had been germinated for 48 h, the amounts of hexa-inositol-phosphates (IP_6) and penta-inositol-phosphates (IP_5) are significantly lower than in the ungerminated flour. We further activated the phytases of the sorghum samples by soaking them in water for 12 h and adjusting the pH in the soaking water to 5.0 by the adding HCl. Figure 1 shows that soaking at optimal pH conditions for the phytases reduces the amounts of IP_6 and IP_5 in the germinated sorghum flour to less than 5% of that in the ungerminated whole flour.

Our next step was to subject the samples to a natural, lactic acid bacterial fermentation. The flours were soaked in water and left at room temperature for 2-3 days; the lactic acid produced in the fermented slurry reduced the pH from an initial value of 6 to about 4. The amount of phytic acid ($IP_6 + IP_5$) is reduced even more in these fermented samples, and the germinated flour has no detectable amounts of IP_6 and IP_5. Table 2 shows a summary of the amounts of IP_6 and IP_5 in μmol/g in the samples studied.

What is the effect of these treatments on iron availability? The iron availability was estimated using an in vitro method developed at our department in Gothenburg (Svanberg et al. 1988). The food sample is progressively digested using a three-enzyme system. The amount of solubilized iron is detected in an atomic absorption spectrophotometer. The relationship between the percentage of solubilized iron and the iron availability measured in human studies using the radio-tag method (Hallberg and Bjorn-Rasmussen 1972) shows a high correlation ($r = 0.99$, $p \leq 0.001$), on 16 different foods with and without animal proteins.

The different sorghum samples in this study were analyzed for soluble iron using this in vitro method. Figure 2 shows the relationship between soluble iron and phytic acid content. The lactic acid fermentation doubles the amount of soluble iron using dehulled flour, and increases it six times using germinated flour.

Table 2. Amount of $IP_6 + IP_5$ (μmol/g) in different sorghum samples; the effects of dehulling, germination, soaking, and fermentation.

Sorghum (white)	Untreated	Soaked (12 h, pH = 6)	Fermented (48 h)
Nongerminated			
Whole flour	5.45	2.70	0.20
85% extracted flour	5.20	2.20	0.40
Germinated			
Whole flour	3.50	0.40	n.d.[a]

[a] Not detectable.

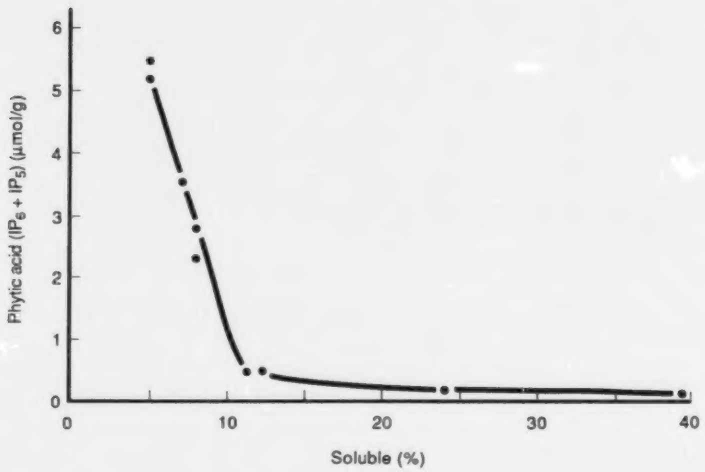

Fig. 2. Soluble iron and phytic acid content in different sorghum samples.

To conclude, traditional, household-level food methods, such as soaking, germination, and fermentation, have been shown under laboratory conditions to reduce significantly the phytic-acid content in white sorghum. The iron solubility, and therefore the iron availability, were increased, depending on the treatment, 2-6 times. In quantitative terms, this means that a diet of "low bioavailability" has been changed into one of "intermediate to high bioavailability"; this could otherwise be achieved only by the inclusion of generous quantities of meat, or of foods containing high amounts of ascorbic acid.

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DISCUSSION SUMMARY

T. Greiner reviewed the conflicting terminologies in use with regard to the weaning period. He also outlined the problems involved in an early introduction of complementary foods, illustrating his theme by reference to the Yemen, where the median age of "sevrage" is 6 months in urban and 12 months in rural areas. He later reviewed his paper on the promotion and support of breastfeeding.

As was emphasized by H. Armstrong, few weaning foods have energy densities anywhere near 70 kcal/100 mL (the energy content of breast milk). There are, therefore, strong grounds for the promotion of prolonged breastfeeding. In discussing the concept of a natural contraceptive strategy, A. Tomkins raised the issues of frequency and duration of suckling. It was pointed out that such a strategy is not feasible for women who work long hours away from home.

U. Svanberg reviewed the advantages of germinated food in terms of energy density, viscosity, and nutrient availability; he noted that were children fed porridges which had their viscostiy reduced using germinated cereals, they would require fewer meals per day to satisfy energy requirements. T. Gopaldas remarked on the rather high intakes per meal reported in Tanzania, compared with those of Indian children. The question was raised of the significance of "power flour"; K.H. Brown suggested that its introduction and promotion was of greater importance than an early introduction of ungerminated solids. Although two participants reported diarrhea as a side effect of power flour, those from JNSP Iringa did not confirm this observation. It was suggested that such diarrhea may have been due to the high sugar content of the food, or to a hydrolysis of the cereals to amyloses that could be osmotically active; there was, however, no data provided. Svanberg described sophisticated technologies used in infant-food manufacture in western countries; these technologies use special chemicals that reduce viscosity and thus produce a liquid feed of high energy density (0.8 kcal/g). It was found in Tanzania, however, that germination of cereals produced results that were just as good. Reviewing the changes in viscosity that are brought about by germination, A.C. Mosha emphasized that the enzyme is active at over 85°C.

S.M. Lorri pointed out that germination is a traditional strategy, and that this technique, together with other components of the GOBI program, had effected a reduction in malnutrition in Iringa during the time of the JNSP. Tomkins cautioned against interpreting the data as representing a significant effect of the power flour: there are many aspects to the JNSP, and he did not consider it valid to single out any individual elements as being responsible for improving nutritional status. Several participants asked for data to show that there had been an overall change in energy intake throughout the day; there was no such data. Other participants requested information on the growth of children receiving power flour, as opposed to that of children being fed ungerminated flour; again, there was no data. Participants also asked for information on morbidity rates, especially on diarrhea attack rates among those using power flour and those using ungerminated flour; there was no such information available.

In a discussion on the acceptability of power flour, L. Hendrata pointed out the considerable potential of social marketing; he stated that it could be presented as powerful - even as magic - and certainly as something new. A number of participants provided evidence as to problems in the acceptance of power flour by adults, particularly by the men, who associate germination mainly with the brewing of beer.

Z. Lukmanji showed a series of tables on food intake at different times and places. Gopaldas suggested that with so many variations in the study groups, these tables were difficult to interpret; she put forward the need for a tighter experimental design. R.P. Kingamkono reported dietary intakes of power flour with rather a high solids concentration. Participants pointed out that this may explain the small increase in dietary intake among the power flour children, as compared with those eating unfermented porridge.

After F. Luhila reviewed her proposed research on the use of germinated flour in Zambia, A. Lechtig emphasized the importance of considering sample size and child selection at this stage of the planning.

Gopaldas raised the issue of adopting a common methodology for feeding trials. She asked whether power flour was in fact a "breakthrough," and whether there could be a place for its social marketing. There were clearly differences of opinion with respect to the testing of power flour: some participants felt that it was important to evaluate further its nutritional impact (on dietary intake and on growth) and its impact on morbidity; others felt that enough is now known on the subject to begin promoting its use.

Gopaldas reviewed the ways in which amylase-rich foods (ARFs) are prepared in India, and mentioned in particular the fact that they have a shelf life of 2-3 weeks. Although the toasting process reduces the water content, it also reduces the amylase content; provided, however, that there are at least 700 maltose units present, there will be sufficient activity to germinate the varieties of cereal in common use.

Y. Vaidya reviewed the use of "sarbottam pitho" in Nepal, emphasizing the need for changes in cooking methods to permit adequate digestibility.

B.L. Amla reviewed his work on the nutritional effects of germinated food in India. Lechtig stated that although the sample sizes used had been small, this was the first study to present objective data on changes in nutritional status (anthropometry and hemoglobin).

Ayebo emphasized the need for nutrition policies that are consistent with those of government. Lechtig expanded on this, stating that there is a great need for nutritional awareness among administrators, planners, etc., in all ministries of government.

There was discussion about the nutrient advantages of germination. Svanberg described the improvement of mineral absorption as a result of destruction of phytates by the germination process. There were problems in extrapolating from studies of nutrient availability in animals, but in general there seemed to be important improvement in micronutrient availability with the use of germinated foods.

There was also considerable discussion about disadvantages in the use of germinated food following the paper by Dendy, which focused on the potential problem of cyanide toxicity of sorghum. There are considerable differences in the cyanide content of different strains of sorghum and there were concerns that a child might be poisoned by eating "kimea." However, it was felt that this would not be a likely occurrence. In the data that Dendy presented, there was evidence that "kimea" (with a potential cyanide content of 400 ppm) would present no problem if it were added soon after the porridge had boiled, because the cyanide would be driven off; if added later, when the porridge was cooler, the cyanide might persist. Even so, the proportion of "kimea" to porridge would always be less than 10%, so the cyanide level would be below 40 ppm (i.e. non-toxic).

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